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Absolute Measurement of Signal Strength on Magnetic Recordings

By ROBERT SCHWARTZ, SHELDON I. WILPON and FRANK A. COMERCI

The Material Laboratory is in the process of developing a method for measuring the magnetic strength existing on 16mm magnetic soundtrack by using a nonmagnetic loop for the determination of the absolute surface induction at 400 cycles/sec for "pegging" the relative surface induction vs. frequency characteristic obtained by the "short gap" or other approved method. This paper shows that this method was found to be practical for determining the surface induction recorded on presently available commercial ¼-in. magnetic tapes, independent of the tape characteristics and the depth of penetration of the recorded signal.

In the past few years, magnetic recording on motion-picture film has come into greater and greater prominence in the motion-picture industry and in U.S. Government applications. The need, therefore, arose of agreeing on standards for the signal level existing on such tracks, comparable to the present SMPTE standard of using a 400-cycles/sec level test film for photographic recording on film.

It was noted in communication between the SMPTE and the Bureau of Ships, that a project to develop a method for measuring the magnetic strength existing on 16mm magnetic soundtrack as a first step in standardization would be beneficial to both agencies. As a result the project was assigned to the Material Laboratory.

Background

A conference was held on Mar. 8, 1954, at the New York offices of the SMPTE to coordinate the efforts of the agencies concerned. Representatives of the SMPTE, Bureau of Ships and the Material Laboratory were present. At that time, the Laboratory presented its general plan of attack to the problem, in which both the SMPTE and Bureau of Ships representatives concurred.

The basis for the program was that a method of measuring relative surface induction over the frequency range by means of the "short gap method"[1,2] or any other approved method would be satisfactory as the first stepping stone. To obtain the "absolute" measurement of magnetic strength on film, it would then be necessary to obtain only one "absolute" measurement at any one discrete frequency and relate it to the relative surface-induction measurement. To perform this one "absolute" measurement, the Laboratory had considered the use of a number of magnetic phenomena, namely, magnetoelectro effects, magnetomechanical effects, magnetothermal effects and magnetooptic effects. However, the magnetic fields required to produce many of these effects appeared to be much greater than the magnetic fields obtainable from magnetic tape or film. The magnetoelectro effect, however, appeared to have possibilities. Therefore, the Laboratory decided that for the present it would restrict the investigation to the use of the magnetoelectro effects to perform the desired measurements.

Two methods were presented by the Material Laboratory. The first method proposed was that the measurement might be obtained in terms of surface induction or voltage output from a specially designed pickup coil or head. The measurement would be made at some frequency in the mid-frequency range, somewhere between 400 and 1000 cycles/sec, as the short-wavelength losses which are the predominant losses in the field of magnetic recording would be minimized. One such type of pickup proposed was a nonmagnetic single turn loop.[3,4] Another type of pickup proposed was a variation of the ring-type reproducing head. For either device, construction of the pickup would have to be simple enough to be made in a machine shop at moderate cost. The effects of physical dimensions, manufacturing tolerances, variations in material composition and wear of the device in use on measurements would have to be determined, using several types of magnetic tapes and films presently manufactured.

A second approach to the problem would involve the deflection of an electron beam of a cathode-ray tube by the relatively weak field of a piece of magnetic-soundtrack film, wherein special construction of a cathode-ray tube would be required to place the film in the electron path of the tube. However, this type of device and other similar proposals would require highly specialized and costly facilities obtainable only at the Material Laboratory or similar establishments. The adoption of such a proposed method of measurement would require that the Laboratory or similar establishment be custodian of a primary standard magnetic-soundtrack film. The secondary standards used by the SMPTE to produce their test films would have to be periodically checked by the Laboratory or a similar establishment. It was concluded at the conference that the obvious advantages of the former method, using a specially designed pickup coil or head, over the latter method seemed sufficient to dictate investigation along these lines prior to the use of any other method.

The Material Laboratory then proceeded with the investigation along the lines of using a nonmagnetic loop as a pickup coil for determining the absolute surface induction at a mid-frequency. This value would then be used to "peg" the relative surface induction vs. frequency characteristic obtained by the "short gap" or other approved method, thus making it possible to obtain the absolute value of surface induction at any point in the frequency range. As the Laboratory, at this time, did not have available a high-quality film-transport mechanism, associated record and reproduce heads and various types of magnetic-coated film, the investigation began using ¼-in. magnetic-recording tape and a professional tape recorder.

Theoretical Considerations

For a practical single-turn nonmagnetic loop, as shown in Fig. 1, where the principal element, the element in contact with the tape, is of a rectangular cross section, the output of the non-

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(This paper was received on October 27, 1954.)

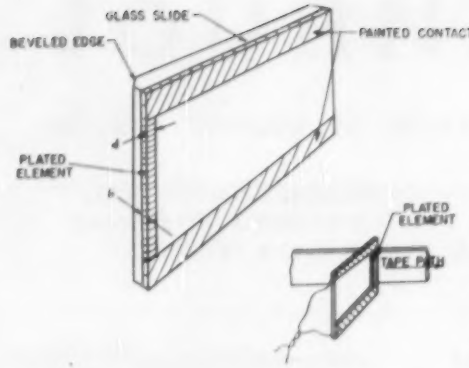

Fig. 1. Sketch of aluminum plated loop.

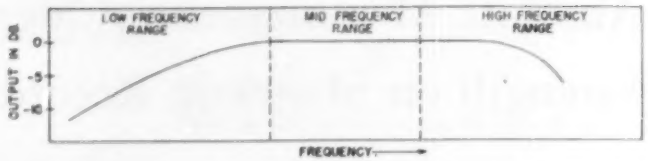

Fig. 2. General overall loop output from recorded tape with "B_y" αf.

magnetic loop as determined by Daniel and Axon[4] is given by

$$\hat{E} = vw\hat{B}_y \left[\frac{1 - e^{-\frac{2\pi d}{\lambda}}}{\frac{2\pi d}{\lambda}} \right] \left[\frac{\sin \frac{\pi b}{\lambda}}{\frac{\pi b}{\lambda}} \right] \quad (1)$$

where

- $\hat{E}$ = peak voltage output from the loop (peak volts);
- v = tape speed (ips);
- w = active tape width (in.);
- $\hat{B}_y$ = peak surface induction normal to and at the surface of the tape (v-sec/sq. in. For $\hat{B}_y$ in gausses, multiply by 1.55×10^8.)
- d = depth of the principal element of the nonmagnetic loop (in.);
- b = width of the principal element of the nonmagnetic loop (in.);
- λ = recorded wavelength (in.).

(In the above equation, it is assumed that there is perfect contact between tape and loop and therefore no "spacing loss." It is also assumed that there is a uniform magnetic field across the width of the tape.) It is noted that in the mid-frequency range where $b << \lambda << d$ Eq. (1) can be reduced to:

$$\hat{E} \cong vw\hat{B}_y \frac{\lambda}{2\pi d} \quad (2)$$

In this range, the loop response (the output voltage as a function of λ for a constant B_y) would therefore have a characteristic which is falling at the rate of 6 db/octave. However, at the low frequencies, when the wavelength is increased and approaches the depth of the principal element (the "d" dimension), the rate of fall of the loop response decreases from the 6 db/octave mid-frequency slope. In addition, at the high frequencies, when the wavelength is decreased and approaches the width of the principal element (the "b" dimension), the rate of fall of the loop response increases from the 6 db/octave mid-frequency slope.

A magnetic tape recorded at a constant current with increasing frequency would have a relative surface induction vs. frequency characteristic, rising at 6 db/octave up to the frequency at which "recording losses" become effective. At this point, the relative surface-induction characteristic would fall off from the 6 db/octave rising characteristic.

From the above considerations, when a tape having a surface-induction characteristic rising at 6 db/octave is reproduced with a nonmagnetic loop, the loop output would have the general frequency-response characteristic shown in Fig. 2. In the mid-frequency range, the output would be flat since the B_y is rising at 6 db/octave and the loop response is falling at 6 db/octave. At the low-frequency and high-frequency ends, a fall off in loop output would occur as a result of the loop response in these regions. The amount of fall off would be a function of d/λ and b/λ, respectively.

By measuring the loop output voltage, $\hat{E}$, the speed of the tape, v, the width of the tape contributing to the flux in the head, w, and the dimensions of the loop "b" and "d"; the peak absolute surface induction normal to the tape, $\hat{B}_y$, can be calculated from the following form of Eq. (1):

$$\hat{B}_y = \frac{\hat{E}}{vw \left[\frac{1 - e^{-\frac{2\pi d}{\lambda}}}{\frac{2\pi d}{\lambda}} \right] \left[\frac{\sin \frac{\pi b}{\lambda}}{\frac{\pi b}{\lambda}} \right]} \quad (3)$$

Procedure

The measurements reported herein were made using an Ampex Model 301 tape recorder operating at a tape speed of 30 ips (inches per second). The 30-ips tape speed rather than 7.2-ips tape speed (the speed of 16mm sound motion-picture equipment) was used for the initial measurements in order to obtain a higher signal voltage from the loop. As the noise output from the loop was essentially hum pickup which did not vary with tape speed, a higher signal-to-noise ratio was obtained. However, the fact that the signal output would be approximately 12 db less at the lower tape speed was considered in determining the feasibility of this method of measurement.

To determine the feasibility of the loop method of measurement, the following points had to be investigated:

A. Method for constructing a practical loop.
   (1) Determination of approximate dimensions of loop to yield maximum signal-to-noise ratio.
   (2) Mounting of loop to result in sufficient sturdiness to prevent variations during measurements.

B. The determination and the measurement of the effective parameters for the calculation of B_y.
   (1) To determine whether the parameters of the equation shown previously are necessary and sufficient for the calculation of B_y under the conditions considered.
   (2) To measure the effective values of the parameters to be used in the calculation of B_y.

C. To determine the suitability of the loop method for obtaining B_y under practical operating conditions.
   (1) Using several loops to determine the extent of variation of the measured B_y among loops.
   (2) Using various tapes with different oxide orientations, oxide coating thickness and oxide surface finishing characteristics to determine whether the effect on the output of the loop is the same as the effect on the output of a playback head.
   (3) Using a tape with signals recorded at various depths of penetration to determine whether the effect on the loop output is the same as the effect on the output of a playback head. (The latter two parts of the investigation were performed in order to determine whether the assumptions under which the equation for loop output was determined are valid under practical operating conditions.)

Results

It was decided to use 400 cycles/sec as the reference frequency at which to determine the absolute surface induction when operating at 7.2 ips. This value would then be used for "pegging" the relative surface-induction characteristic. The

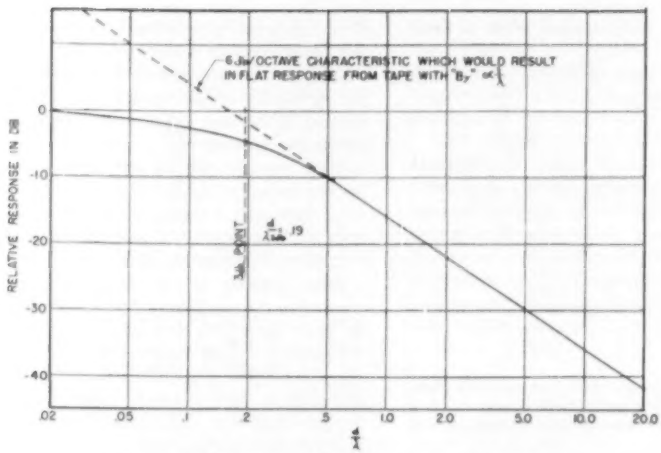

Fig. 3. Effect of "d" dimension on loop output.

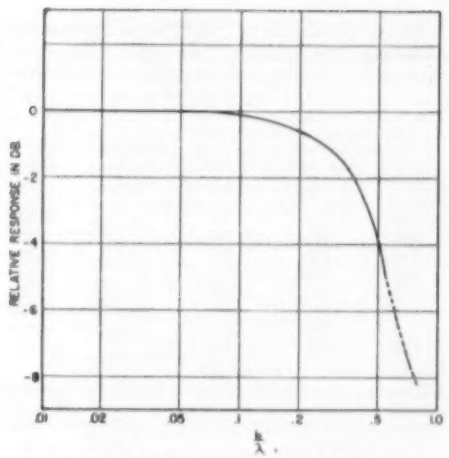

Fig. 4. Effect of "b" dimension on loop output.

400 cycles/sec was selected because it is in the mid-frequency range, and therefore, the wavelength losses for this frequency, at the speeds to be used, are minimized, and also, because most of the 16mm motion-picture sound standards are based on this frequency. However, since 30 ips was used as the tape speed for most measurements, 1600 cycles/sec was used; as its recorded wavelength would be approximately equal to the recorded wavelength of 400 cycles/sec at the 7.2-ips tape speed.

One of the first problems encountered was in making the loops. It was found that to minimize the loop losses to obtain maximum loop output for an approximately 18-mil wavelength (400 cycles/sec at 7.2 ips), the dimensions of the principal element of the loop would have to be approximately $\frac{1}{64}$ in. in depth ("d" dimension) and a maximum of approximately 1 mil in width ("b" dimension). It was difficult to mount a nonmagnetic foil or wire of these dimensions in a usable mount as had been done by Daniel and Axon.[4] Instead of using a nonmagnetic foil for this element, it was decided to plate the edge of a sheet of glass with a nonmagnetic conducting material. Aluminum was selected as the plating material to be used. The sheet of glass was masked to give the "d" dimension of $\frac{1}{64}$ in. The plating thickness controlled the "b" dimension. The glass was plated using the "Vacuum Evaporation Process." Low resistance contacts were painted on the glass with silver conducting paint which connected to the principal element as shown in Fig. 1. A mount was designed and built to hold the glass slide and to permit proper alignment of the loop with the signal on the tape.

As the output of the loop was very low (in the order of a few microvolts), amplifiers and filters were employed to obtain a usable signal-to-noise ratio.

The initial approach, using the loop method, was to determine, with different loops, the B_y of a 1600-cycles/sec signal on a pre-recorded tape by using Eq. (3). (The tape was recorded to have a relative surface-induction characteristic rising at 6 db/octave.) This measurement was made to determine whether the results could be duplicated with different loops. It was accomplished by determining the dimensions of the principal element of each loop, measuring the loop output from the 1600-cycles/sec signal on the pre-recorded tape with each loop, and assuming the speed, effective tape width, amplifier gain and dimensional constants to be lumped as a single constant, K (to be investigated later—an approximate value for K is 146, for $B_{y(rms)}$ in gauss). The dimensions were determined by finding the 3-db point at the low end and high end of the loop response with the pre-recorded tape. Relating this data to a plot of

$$20 \log_{10} \frac{1 - e^{\frac{-2\pi d}{\lambda}}}{\frac{2\pi d}{\lambda}} \text{ vs. } \frac{d}{\lambda}$$

shown in Fig. 3 (low-frequency loss in db as a function of d/λ) and a plot of

$$20 \log_{10} \frac{\sin \frac{\pi b}{\lambda}}{\frac{\pi b}{\lambda}} \text{ vs. } \frac{b}{\lambda}$$

shown in Fig. 4 (high-frequency loss in db as a function of b/λ), the effective "d" and "b" were determined. This method rather than a direct method (such as a microscope) was used in order to account for any irregularities in the plating. The "d" values obtained were of the order of magnitude measured with a microscope, but the "b" values calculated were of much larger magnitudes than the 0.5 mil approximated with a microscope. A "b" value of 0.5 mil would result in 3-db drop-off at the high-frequency end at approximately 27,000 cycles/sec, using a 30-ips tape speed. This would make the losses due to the "b" dimension negligible at the wavelengths considered. However, in making the measurements, the 3-db drop-off at the high-frequency end was found to occur at a much lower value. It therefore appeared that an additional loss besides those due to the "b" and "d" dimensions of the loop would have to be accounted for. Upon close examination of the plating of the loops, it was found that the plating did not extend to the very edge of the glass due to the edge of glass not being sufficiently polished prior to plating. It was expected that a "spacing loss" existed which overshadowed the losses due to the "b" dimension.

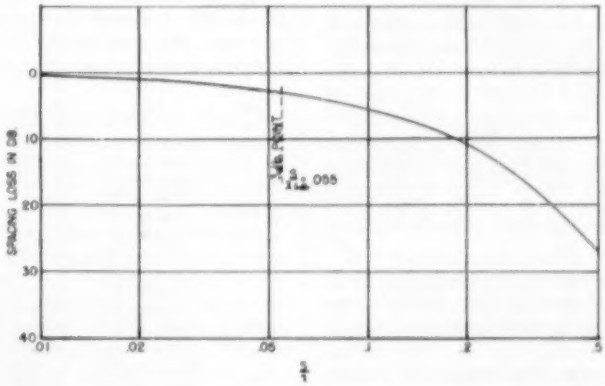

Fig. 5. Spacing loss vs. S/λ (spacing loss in db = $20 \log_{10} e^{\frac{-2\pi S}{\lambda}}$).

Table I. Tabulation of "B_y" for a Pre-Recorded Tape Determined With Several Aluminum Plated Loops. (Tape Speed 30 ips).

Loop no.	Low end 3-db point, cycles/sec	High end 3-db point, cycles/sec	Effective "d" value, mils	Spacing value, mils	Loop output* at 1600 cycles/sec db ref 0.001, volt (rms)	B_y †(rms)	Relative B_y, db
13A	370	2000	15.4	0.825	26.3	0.140K	2.9
14A	345	1600	16.5	1.03	24.0	0.128K	2.2
15A	365	1850	15.6	0.895	26.0	0.144K	3.2
16A	360	1900	15.8	0.870	25.2	0.128K	2.2
17A	350	2500	16.3	0.660	26.3	0.140K	2.9
18A	365	2350	15.6	0.705	24.9	0.120K	1.6
21A	350	1780	16.3	0.929	25.7	0.145K	3.2
22A	335	1900	17.0	0.869	24.5	0.130K	2.3

* Includes overall system amplification.
† K is a function of the width of the recorded tape comparative to the length of the loop, recorder speed, gain of amplifiers and dimensional constants. For $B_{y(rms)}$ in gauss, K ≅ 146.

Daniel and Axon[4] derived the equation for the output of the nonmagnetic loop assuming no "spacing loss." However, when a spacing "S" is assumed, Eq. (1) would be modified as follows:

$$\hat{E} = vw\hat{B}_y e^{\frac{-2\pi S}{\lambda}} \frac{1 - e^{\frac{-2\pi d}{\lambda}}}{\frac{2\pi d}{\lambda}} \frac{\sin \frac{\pi b}{\lambda}}{\frac{\pi b}{\lambda}} \quad (4)$$

This equation is obtained by changing the limits of the second integral of the equation on p. 166 of the paper by Daniel and Axon.[4]

$$\hat{E} = -\frac{v\hat{B}_y}{bd} \int_{-\frac{w}{2}}^{\frac{w}{2}} \int_0^d \int_\pi^{x+b} e^{-\frac{2\pi y'}{\lambda}} \cos \frac{2\pi x'}{\lambda} \, dx' \, dy' \, dz' \quad (5)$$

from 0, d to S, S + d respectively, thus accounting for any spacing between the tape and the loop. Incidently, the factor $e^{-\frac{2\pi S}{\lambda}}$ which accounts for the "spacing loss" in this equation is the same factor determined by Wallace[5] for a reproducing head. The spacing "S" was determined from the frequency at which the loop response from the pre-recorded tape was down 3 db on the high-frequency end and the equation:

$$\text{Spacing loss in db} = 20 \log_{10} e^{\frac{2\pi s}{\lambda}} \quad (6)$$

This "spacing loss" characteristic is plotted in Fig. 5. To calculate B_y the following equation was used:

$$B_{y(rms)} = \frac{E_{(rms)}}{vw\left[e^{-\frac{2\pi s}{\lambda}}\right]\left[\frac{1 - e^{-\frac{2\pi d}{\lambda}}}{\frac{2\pi d}{\lambda}}\right]\left[\frac{\sin \frac{\pi b}{\lambda}}{\frac{\pi b}{\lambda}}\right]} \quad (7)$$

where, in this case, the loss factor due to the "b" dimension, the quantity in the third bracket in the denominator, is equal to 1.

The data and the resulting B_y (for the 1600-cycles/sec signal on the pre-recorded tape) determined with eight different loops are tabulated in Table I. The variation from the largest to the smallest value of the B_y obtained was only 1.6 db.

As the loop output voltage may possibly be affected by the oxide orientation of the tape or film, a test was performed in which the B_y was determined by the loop method for tapes of various oxide orientations where the signal was recorded on each type of tape to give the same output from a reproduce head. Five different commercially available tapes known to have different oxide orientation, oxide thickness and oxide surface finishing characteristics were recorded with a fixed-bias current, and the loop output was measured. As shown in Table II, recordings on various tapes which produced constant outputs from a magnetic playback head, resulted in only minor variations in B_y as determined with each of three loops. This indicated that the B_y as measured with the loop is substantially indicative of the playback-head output, or the voltage-inducing flux in the playback-head core, in spite of differences in oxide orientation and other tape characteristics exemplified by presently available tapes.

Table II. Comparison Between Loop Output and Playback-Head Output With Tapes of Different Oxide Orientation. (Recording Prepared for Constant Output from Playback Head).

Loop no.	Type of tape	$B_{y(rms)}$	Relative B_y, db
31A	Oriented I	0.143K	3.1
	Oriented II	0.138K	2.8
	Oriented III	0.143K	3.1
	Oriented IV	0.143K	3.1
	Oriented V	0.136K	2.7
33A	Oriented I	0.129K	2.2
	Oriented II	0.129K	2.2
	Oriented III	0.134K	2.5
	Oriented IV	0.136K	2.7
	Oriented V	0.134K	2.5
35A	Oriented I	0.136K	2.7
	Oriented II	0.134K	2.5
	Oriented III	0.136K	2.7
	Oriented IV	0.138K	2.8
	Oriented V	0.130K	2.3

As the depth of penetration may affect the loop output under practical conditions (i.e. if the assumptions made in the derivation of the equation for determining B_y are not valid under practical operating conditions), a test was performed wherein the B_y was determined by the loop method for signals recorded on a tape with varying depths of penetration. The depth of penetration was varied by changing the bias current from a relative value of 110 ma to 300 ma, where the range of bias current extended in both directions beyond the current necessary for peak output from the tape considered. The input of the recorder was adjusted to give constant output from the playback head. The output of each of three loops was measured for each of the bias-current settings. As shown in Table III, for various depth recordings which produced constant output from the playback head, the variations in loop output for each of the three loops used were very small. This implies that the B_y as measured with the loop is substantially indicative of the playback-head output in spite of variations in depth of penetration.

Table III. Comparison Between Loop Output and Playback-Head Output With Variations of Depth of Penetration of Recorded Signals. (Recording Prepared for Constant Output From Playback Head).

Loop no.	Relative bias current, ma	$B_{y(rms)}$	Relative B_y, db
31A	110	0.148K	3.4
	120	0.148K	3.4
	130	0.149K	3.5
	140	0.148K	3.4
	200	0.146K	3.3
	300	0.148K	3.4
33A	110	0.129K	2.2
	120	0.128K	2.1
	130	0.129K	2.2
	140	0.129K	2.2
	200	0.129K	2.2
	300	0.129K	2.2
35A	110	0.136K	2.6
	120	0.138K	2.7
	130	0.136K	2.6
	140	0.136K	2.6
	200	0.136K	2.6
	300	0.136K	2.6

To check the repeatability of the measurements with the same loop, a 1600-cycles/sec signal was recorded on a tape (tape speed 30 ips). A loop was placed in the mount, aligned, and the output of the loop was noted when the pre-recorded tape was reproduced. The B_y was then calculated. The above operations were repeated four times using the same recording. From the results tabulated in Table IV, it can be seen that the values obtained for B_y by the loop method are adequately repeatable, as the maximum variation for the five measurements was only 0.6 db.

Table IV. Measurement of "B_y" With the Same Loop for Indication of Repeatability of Measurement.

Run no.	$B_{y(rms)}$	Relative B_y, db
1	0.105K	0.4
2	0.108K	0.6
3	0.100K	0
4	0.101K	0.1
5	0.102K	0.1

Conclusions

The results of this phase of the investigation, using ¼-in. magnetic tape, indicated the feasibility of this method for measuring the "absolute" magnetic strength of a recorded tape. From the data obtained, it can be seen that measurement of B_y for a given signal with different loops showed variations of only approximately 1.6 db. With a single loop the measurement of B_y repeated within 0.6 db. It was also found that the B_y as determined with the loop corresponded to the output from a magnetic head in spite of presently existing variations in the tape oxide orientation, depth of penetration of the recorded signals and other tape characteristics.

Acknowledgments

The Material Laboratory has recently received 16mm magnetic sound motion-picture equipment from various manufacturers for use in the extension of this project to 16mm magnetic soundtracks. The authors take this opportunity to thank the following manufacturers for their cooperation: Audio Devices, Inc.; Bell & Howell Co.; Brush Electronics Co.; Magnasync Mfg. Co., Ltd.; Minnesota Mining and Mfg. Co.; Pampa Electronics Sales Corp.; Reeves Soundcraft Corp.; and Wilbur Machine Co., Inc.

The writers also wish to thank Mr. E. Haas, Head of the Physical Chemistry Section of the Material Laboratory for his assistance in manufacturing the nonmagnetic loops, and the members of the Society of Motion Picture and Television Engineers and representatives of the Bureau of Ships who helped to expedite this project.

References

1. J. D. Bick, "Methods of measuring surface induction of magnetic tape," *J. Audio Eng. Soc., 1:* 4, Jan. 1953. Reprinted, *Jour. SMPTE, 60:* 516–525, April (Pt. II) 1953.
2. Standards of Sound Recording for the International Exchange of Programmes; (Draft Recommendation) Resolution No. 4, Doc. 24E of 8 Sept. 1952 Meeting C.C.I.R. Study Group X, Geneva 1952.
3. United Kingdom Frequency Characteristic Standardization in Magnetic Recording; Question No. 63; VIIth Plenary Assembly C.C.I.R., Study Group X, 00.30/4/53.
4. E. D. Daniel and P. E. Axon, "The reproduction of signals recorded on magnetic tape," *Proc. IEE, Part III:* 157, May 1953.
5. R. L. Wallace, Jr., "Reproduction of magnetically recorded signals," *Bell Sys. Tech. J., 30:* Pt. 2, 1145–1173, Oct. 1951, (Monograph 1924).

Discussion

Malcolm G. Townsley (Bell & Howell Co.): With the output voltages of the loop as low as they were — a few microvolts — how good a signal-to-noise ratio were you able to get in your measurements?

Mr. Comerci: We were able to get about 15-db signal-to-noise ratio operating at 30 ips — that is, using bandpass filters. We used half-octave filters. With the magnetic striping I think we will work with signal-to-noise ratios of 5 to 6 db, maybe as high as 10 db.

[In the presentation of this paper Mr. Comerci spoke of the possibility that although two tapes with certain recordings may produce equal output levels on one reproduce head, they may not produce equal output on another reproduce head. This does not appear in the published paper.]

Jerome W. Stafford (M-G-M Sound Dept.): Since it's the normal component of induction that you are working with, how much variation do you find due to geometry in passing over the head? Is there any variation in this respect?

Mr. Comerci: You are talking about the geometry of a magnetic head? Geometry is usually reflected in what we call boundary effects down at the very low frequencies. Is this what you mean?

Mr. Stafford: I was wondering if that could possibly be an explanation of the difference in sensitivity of the various types of head?

Mr. Comerci: No, I doubt it, and this is the reason. In reading through the literature we all get the idea, in those frequencies below 1000 cycles, that the response of any magnetic head rises to 6 db/octave. We have used, let us say, a high-quality head, and we find it is more of the order of 5½ db/octave rather than 6 db/octave. At the time we tried this we thought that it might be due to spacing loss. We used a tape that was recorded at a constant current and we should have expected a 6-db rising characteristic, but instead we got 5½ db/octave. We had a machine which employed a pressure pad against the tape, where the spacing loss should have been lower. We tried the tape on this machine and instead of increasing the 5½-db rise it reduced it to 4½ db. This could be caused either by the half-width track in the reproduce head or the reproduce head or the reluctance of the magnetic path. We have to do more work to find an explanation. I don't think it was what is generally called contour effect. Contour effect changes with wavelength and within the limits of our measurements we found a 5½ db/octave rise. It was linear, it wasn't something that was high at one frequency and low at another.

A Method for Splicing Motion-Picture Film

By V. C. CHAMBERS and W. R. HOLM

The splicing of motion-picture film with pressure sensitive tape is described. A tape made from thin "Mylar" polyester film has been found to yield strong, durable splices without the need of scraping or cementing. This method is applicable to all types of film base, and may have utility in theaters or as a replacement for clip, staple or stitch splices in laboratories.

The Photo Products Department of E. I. du Pont de Nemours & Company has developed and is preparing to introduce commercially a new, synthetic safety film support known as "Cronar" polyester photographic film base. This new film base cannot be spliced with the film cements conventionally used to splice existing motion-picture films. Accordingly we have done considerable research to develop satisfactory methods for splicing motion-picture film made on Cronar base to itself and to existing motion-picture film bases. Techniques for accomplishing this are in final stages of development and include methods that are patterned after existing splicing operations. However, one technique that we have investigated is quite different from those used extensively today and because it appears to have advantages over existing methods for several motion-picture applications involving any film base, we are presenting the results of the study at this time. Briefly, it has been found that motion-picture film can be very satisfactorily spliced by applying with a suitable applicator to both sides of the film a thin "Mylar" polyester film coated with a transparent adhesive. The possibility of using this technique was brought to our attention by H. W. Moyse.

Presented on October 21, 1954, at the Society's Convention at Los Angeles, by V. C. Chambers and W. R. Holm (who read the paper), Photo Products Dept., E. I. du Pont de Nemours & Co., Parlin, N.J.
(This paper was received on November 22, 1954.)

Pressure-Sensitive Tape Splices

The splices are similar to those used for splicing magnetic oxide sound recording film. The perforated tape is made from 1-mil thick Mylar polyester film coated with a transparent adhesive about 0.5 mil thick, making the total tape thickness nominally 1.5 mils. Splices are made by applying pieces of this tape

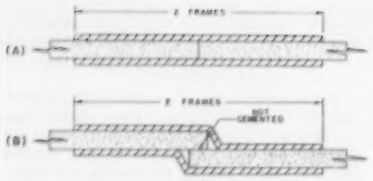

Fig. 1. Tape splices on 6-mil film: (A) butt splice—total thickness = 9 mils; (B) lap splice—total thickness = 15 mils.

two frames long to both sides of the film, as shown schematically in Fig. 1. Figure 1-A shows a butt splice, the total thickness of which is 9 mils for a 6-mil film. Figure 1-B shows a lap splice, the total thickness of which is 15 mils. This latter splice may be made either to full-hole or to half-hole dimensions without significantly affecting the strength of the splice. Neither the butt nor the lap splice requires scraping or cementing.

The Tape Splicer

When applying the tape to the film, we have found that two conditions must be met if the splice is not to be apparent on the screen. First, the edges of the tape must be outside the frame; second, the tape must be applied smoothly without wrinkles or trapped air bubbles. The splicing device shown in Fig. 2 is an experimental model that we have developed. It meets the requirements reasonably well but undoubtedly better and simpler splicers can be made.

As can be seen from Fig. 3-A, the perforated tape is fed from the supply spool onto the sprocket wheel of the tape dispenser, with the nonadhesive side of the tape against the sprocket. This wheel is slotted in four places around its circumference so that the knife-blade shown can cut a two-frame length of tape to be dispensed.

To make a splice with this device the two lengths of film to be joined are positioned onto the registering pins of the base unit, shown in Fig. 3-B. Actuating the plunger at the forward end of the dispenser unit causes the knife-blade to cut a two-frame length of tape on the sprocket wheel. Now the dispenser unit is positioned into channels in the base unit and moved from right to left. This rolls the precut length of tape off the sprocket wheel and applies it, in register, to the films to be spliced. The film is then turned over and the operation repeated to complete the splice. The dispenser cannot be positioned into the channels of the base unit unless the knife-blade plunger has been actuated to cut off a two-frame length of tape.

Rolling the tape off a sprocket wheel is one way to apply it smoothly, in register with the film, and without occluding air bubbles. As is well known, there are other ways to apply perforated adhesive tape to film, some of which may be more attractive than the method shown here.

Laboratory Data

Mylar film and the adhesive layer are essentially transparent and colorless, and when applied to both sides of a motion-picture film reduce the optical transmission of the two frames involved by only about 7%, an amount which allows the splice to go completely unnoticed on the screen.

Stress-strain curves for butt, and half-hole lap splices made with tapes from two different sources are shown in Fig. 4, together with a curve for unspliced cellulose triacetate film. These curves, made on an Instron Tensile Tester, show that for load values far in excess of those which perforations can withstand, the elongation of any of the tape splices is indistinguishable from that of the unspliced film. At the point where the splice curves show departure from the curve for the unspliced film, the load is more than five times that at which the perforations would be torn from the film.

The two tapes shown were obtained from two different manufacturers. The curves labelled "commercial tape" represent a butt and a half-hole lap splice made with commercially available tape. The curves labelled "experimental tape" represent similar splices made with a tape which should soon be commercially available. It can be seen that the experimental tape splices approach very closely the tensile properties of the unspliced base. This may be important for some uses, though far beyond projection requirements.

In addition to the tensile tests represented by Fig. 4, a dynamic stress-strain test of both lap and butt tape splices was carried out on the Instron machine. In this test a 5-lb stress was applied and relieved 120 times, and a 20-lb stress was applied and relieved 40 times, each over a 10-min period at room temperature, 74 F. Yet, as a result of this test, the tape splices showed no measurable deviation from the behavior of unspliced cellulose triacetate film. It is well known that even a 5-lb load, applied at these low frequencies to triacetate film running over a sprocket, is more than enough to completely strip the perforations.

Tests of tensile strengths of butt splices made at a range of relative humidities confirm the general impression that there should be little change with humidity. The data obtained at 74 F to 77 F, which are typical of those for other temperatures are shown in Fig. 5. At high humidities, 95% to 100%, there is some reduction in ultimate strength though the splice showed satisfactory behavior for stresses much in excess of the strength of perforations as they run on sprockets. It is interesting to note that all the curves presented, including two for unspliced film, show the same elastic behavior at the low loads to be expected in normal film handling, quite independent of humidity.

An effect of temperature on splice tensile strength was expected and found as shown in Fig. 6. No significant difference is shown in the stress range of nor-

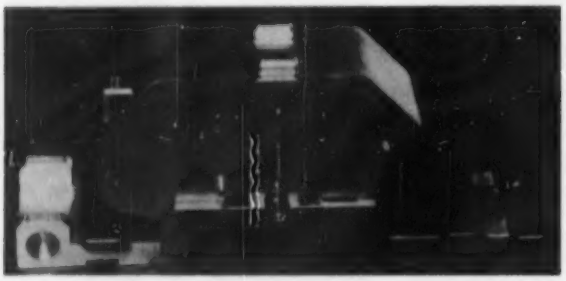

Fig. 2. Photograph of tape splicer (complete unit).

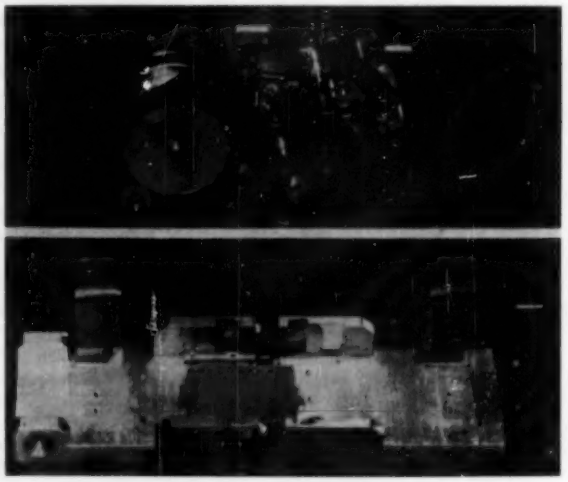

Fig. 3. (Above) The dispenser unit with side plate removed, showing supply spool, sprocket wheel and knife-blade; (below) the base unit, showing registering pins and channels to receive dispenser.

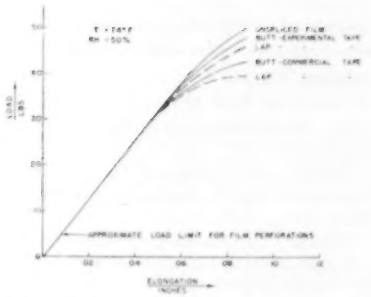

Fig. 4. Stress-strain behavior of adhesive tape splices and cellulose triacetate film (74 F, RH 50%)

mal operations. The curves cover the temperature range 75 F to 140 F. An additional strength test, which could not be run on the same equipment, was made at −26 F and showed good strength.

The investigation of high-temperature phenomena was extended to cover an additional factor, creep of the adhesive bond under sustained loading. Even casual examination shows that the rate and duration of load application affects the result. The curves of Fig. 6 were obtained on the Instron Tester set to strain the film at a rate of 0.2 in./min. This is, of course, a very low rate in comparison with phenomena occurring in motion-picture projection. The equipment available could be increased in speed by a factor of ten, which is still slow in comparison with projector movement. It is interesting to note however, that this change, shown in Fig. 7, nearly doubled the effective strength of the splice at the 120 F temperature. Under sustained load creep did take place. Figure 8 shows the rate of creep at various temperatures under 5.2-lb average load. Creep is, of course, inelastic behavior, and so the give under this 5.2-lb continued pull is quite a contrast to the elastic behavior to a more than 20-lb limit when the load was quickly applied. Motion-picture projection equipment in normal use never applies the long continued stress and hence uses this type of splice under most advantageous conditions.

Creep and the dynamic characteristics of the splices were found essentially un-

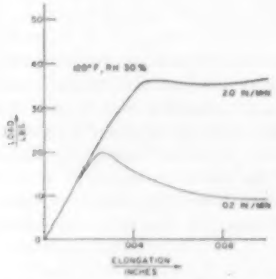

Fig. 7. Stress-strain behavior of adhesive tape splices at different rates of elongation.

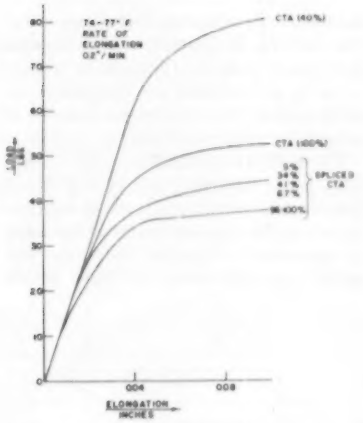

Fig. 5. Stress-strain behavior of adhesive tape splices and cellulose triacetate film at different relative humidities.

affected by changes of relative humidity from 5% to 100%.

No tendency for the adhesive to bleed was noticed, even at temperatures above 100 F. No measurable slippage of tape splices could be induced by continuous high-intensity arc projection of film loops, by aging tightly wound rolls, or by repeated rewinding of rolls under tension at 150 F. During high-intensity projection of loops of black-and-white film, blistering of the emulsion took place before the tape splices were affected by the heat.

Because of the high tear strength of the Mylar polyester film from which the tape is made, the tear strength of the tape splices is considerably greater than that of triacetate film.

Both lap and butt splices have been cleaned with commonly used film cleaning solutions such as Oronite, made by the Oronite Chemical Co., "Freon-113" trichlorotrifluoroethane, trichloroethylene, alcohol and ammonia, carbon tetrachloride and gasoline, without loosening the tape. Yet these tape splices can be taken apart and the films respliced without any loss of frames.

Laboratory Projection Tests

Both lap and butt splices have shown good screen steadiness and have run smoothly through a projector in laboratory tests. Most samples tested have been projected in loops more than 1000 times without splice failure. Some of the butt splices tended to become noisy after 50 to 100 projections, due to the flexing of the butt joint. This causes the film loop to slap just before it enters the projector gate. Lap splices, having greater stiffness, do not show this effect, though they sometimes tend to fail earlier than butt splices. This may be due to the uncemented overlapped ends exerting a lifting force which tends to loosen the tape bond as the splice bends around rollers and sprockets.

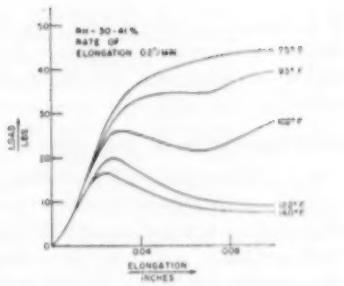

Fig. 6. Stress-strain behavior of adhesive tape splices at different temperatures.

As must be expected even with splices such as these, there are factors which make some last longer than others. Yet the minimum number of projections for any tape splice we have made was 345 runs. The great majority of tape splices have outlasted the film when attempts have been made to run them to destruction.

Tape Splices in Theaters

It is a matter of common knowledge that film splices have long been a problem in theaters, and that poor splices can be found in almost any reel of release positive film. A bad scrape, bad application of cement, the wrong cement, uneven pressure, an unsatisfactory amount of cement — any of these factors — can cause a poor splice and a potential film break in a projector.

Some projectionists actually take the precaution to stick a piece of ordinary transparent adjesive tape over every cement splice in a reel before projecting it, claiming that this piece of tape often prevents a film break when the cemented bond fails. Perhaps it should come as no surprise then that most of the projectionists who have become acquainted with tape splicing have been enthusiastic, even to the point of offering to buy one

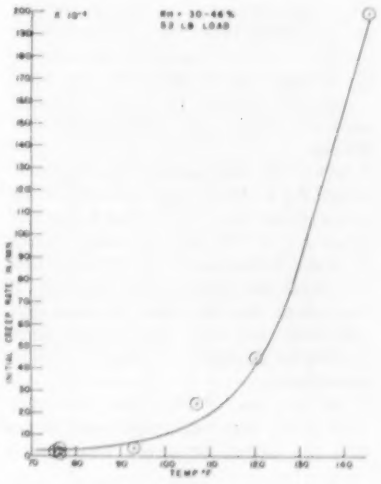

Fig. 8. Creep behavior of adhesive tape splices vs. temperature.

of our splicers. In view of these data and results it seems apparent that tape splicing of motion-picture film is of real utility.

Other Applications for Tape Splices

Butt splices made with a tape using an opaque, water-resistant adhesive have been used for splicing rawstock for both black-and-white and color processing. The processing solutions did not loosen the tape, even when applied to the emulsion surface. It appears, therefore, that tape splices may be of interest to laboratories as an alternate for clip, staple or stitch splices. Tape splices may also be of interest for negative repairing.

The utility of tape splicing in the 16 mm field, while not discussed in this paper may even be greater than for 35 mm applications. During the course of this work we have been in contact with tape and splicer manufacturers. All have shown considerable interest in developing the materials and equipment needed for tape splicing. The Du Pont Company is ready to cooperate with any who may wish to carry this development further.

"Mylar" and "Freon-113" are registered trade-marks of E. I. du Pont de Nemours & Company, (Inc.).

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Color-Television Coaxial Cable Termination and Equalization

By W. B. WHALLEY

The critical requirements of NTSC color signal transmission make it necessary to analyse the characteristics of the coaxial cable used for this purpose within a television studio. This paper describes (a) the development of multi-element terminations to match the variation of cable impedance with frequency, (b) the design of networks to compensate for amplifier input capacitance, and (c) the provision of precise amplitude equalizers to compensate for cable attenuation.

In monochrome television the usual viewpoint has been that each type of coaxial cable used in a studio plant has a single value of iterative impedance and a smooth variation of attenuation with frequency. Investigation shows, however, that the cable characteristics vary markedly with frequency, particularly at the lower video frequencies. In a color-television broadcasting plant it is important that steps be taken to correct for this phenomenon since the FCC-approved, NTSC color-television system requires high accuracy in the overall system performance in order to provide good reproduction. System characteristics which are of secondary importance in monochrome broadcasting can have a major effect upon hue, saturation and both luminance and chrominance resolution.

Since the hue information is determined by a vector angle having a total range of less than 1 cycle at a subcarrier frequency of 3.58 mc, any small change in phase angle anywhere in the system can cause an error in hue. Further, if the system does not have constant gain with frequency to at least 4.2 mc, there can also be changes in the degree of color saturation.

An analysis of the *delay* tolerance throughout the video spectrum shows that the higher frequency components in the region of the subcarrier and its sidebands must arrive at the reproducing device at the same time as the low frequency luminance components, (15,734 cycles/sec and multiples thereof). Any change in time of arrival can cause a decrease in overall picture resolution, because of the color components (I and Q) of the signal arriving out of time registration with the luminance components (Y). The NTSC specifies that the *overall system* (studio, Telco circuits, transmitter and receiver) delay variation between the 15,734 cycles/sec and the 3.58 mc components should not exceed ± 0.05 μsec.

In order to meet these delay limits, the transmission system in a color-television studio plant must have a maximum variation in delay throughout the video band appreciably less than that allowed for the complete system. A tolerance of ± 0.02 μsec seems a reasonable objective. Hence, all components must be carefully compensated for phase as well as for amplitude.

Since the gain-versus-frequency characteristic of the *overall system* is also specified by NTSC to be within 2 db from 15,734 cycles/sec to 4.2 mc, the *studio* portion should be constant within less than 1 db. Because of the many sections of coaxial cable and the many amplifiers which are in tandem in a typical studio plant the maximum error in any run of cable should be less than 0.2 db (i.e., 2.2% in voltage). To provide some safety factor, the coaxial cables should be compensated to a somewhat higher frequency than the color television bandwidth; probably to at least 6 mc.

A contribution submitted on November 12, 1954, by W. B. Whalley, CBS Television, 485 Madison Ave., New York 22, N.Y.

Characteristics of Coaxial Cables

In many types of cable, the properties at all frequencies vary during manufacturing, and are dependent upon the operating temperature. Therefore, to improve the stability of a color television transmission system, it is necessary to choose a type of cable which has close tolerance in manufacturing and does not change appreciably with age. There must be constancy of wire and dielectric diameters, and accuracy of control of concentricity. If there is variation in concentricity, there will be changes in impedance along each length of cable, making it impossible to correctly match the line with a single termination. Also, the center conductor should have a plain copper surface since tinned surfaces increase in resistivity with life.

The iterative impedance of any cable increases rapidly in phase and magnitude with decreasing frequency below 200 kc. The basic equation is:

$$Z_I = \sqrt{\frac{r + jl\omega}{g + jc\omega}} \qquad (1)$$

where r, l, g and c are, respectively, the resistance, inductance, shunt conductance and capacitance per unit length. To maintain the iterative impedance Z_I constant, r/g must equal l/c. However, since the shunt conductivity of present-day video cables is effectively zero, the above equation can be written thus:

$$Z_I = \sqrt{\frac{l}{c} - j\frac{1}{\omega}\frac{r}{c}} \qquad (2)$$

It must be noted, however, that r and l vary with frequency and that the

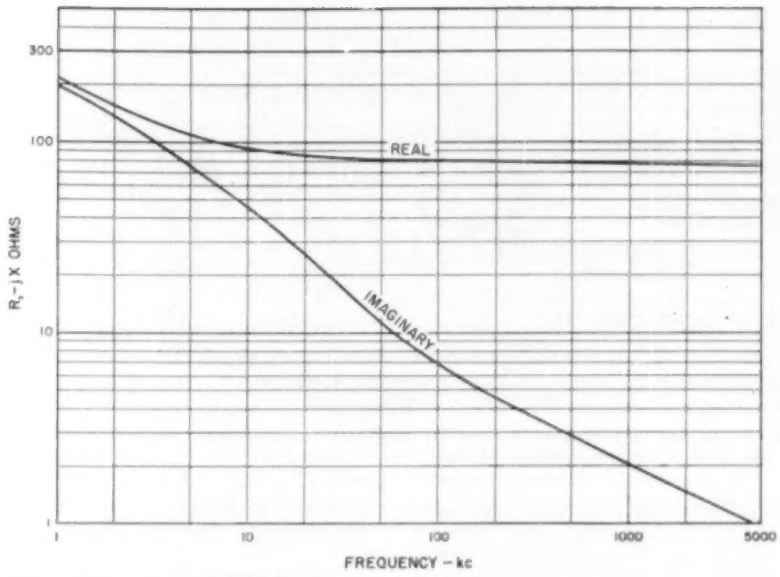


Fig. 1. Iterative Impedance of WE724 coaxial cable showing the rapid increase in impedance, particularly in reactance, with decreasing video frequency, typical of all low attenuation coaxial cables.

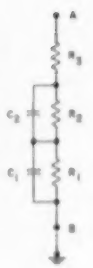


Fig. 2. Schematic of a five element network which with correct values of R_3, R_2, R_1, C_2 and C_1, can match the iterative impedance of a cable over a wide range of frequency. When grounded at B, it becomes a receiving end complex termination.

Fig. 3. Sample work sheet of equivalent series R^1 and $-jX$ at 15 kc for a range of values of parallel R and C. From this and similar work sheets at 40, 5, 3 and 1 kc, successive values of R and C were chosen to finally arrive at satisfactory combinations of R_3, C_2, R_1, C_1 for the necessary complex terminations.

attenuation curves for presently used coaxial cables have two regions of discontinuity, both below 1 mc.

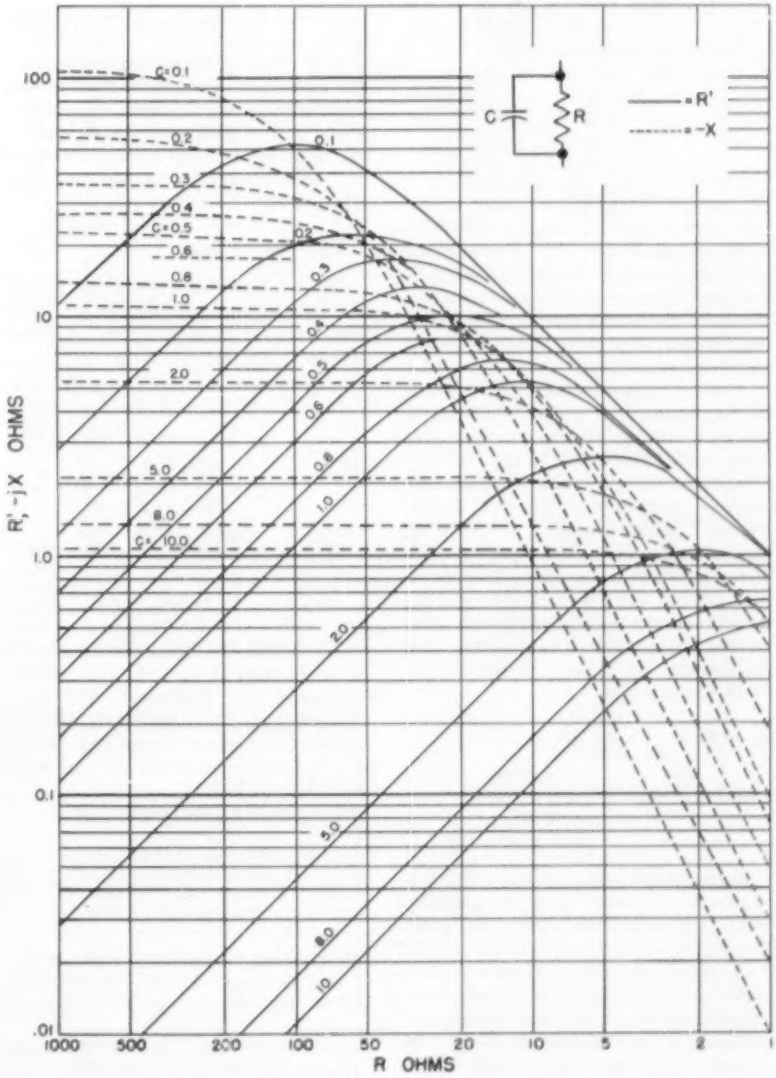
Changes in temperature cause the resistance of the cable to change proportional to the temperature coefficient of resistance. For copper this represents a change of 0.4% per degree centigrade. Large changes in temperature can, therefore, change Z_I and the attenuation of the cable.

Complex Terminations

A simple resistance termination can cause undesirable changes in both phase and voltage of the received signal at the lower video frequencies. The change of Z_I with frequency below 200 kc, may be compensated for by one of two methods. The conductance of the cable may be changed, so that $r/g = l/c$, by, for example, adding shunt resistors at suitable points.[1] This method has certain disadvantages, such as the numerous extra splices required, and the increase in attenuation. The other method is to use complex terminations whose impedance characteristics vary with frequency in a similar manner to the cable. It is advisable to have such complex terminations at both ends of each long cable run, since then the correct termination is independent of the length of the cable.

Equation (2) shows that Z_I is capacitive at lower frequencies. For example,

[1] Joseph Fisher, "TV distribution system for laboratory use," *Communications, 29:* No. 2, p. 42, Feb. 1949.



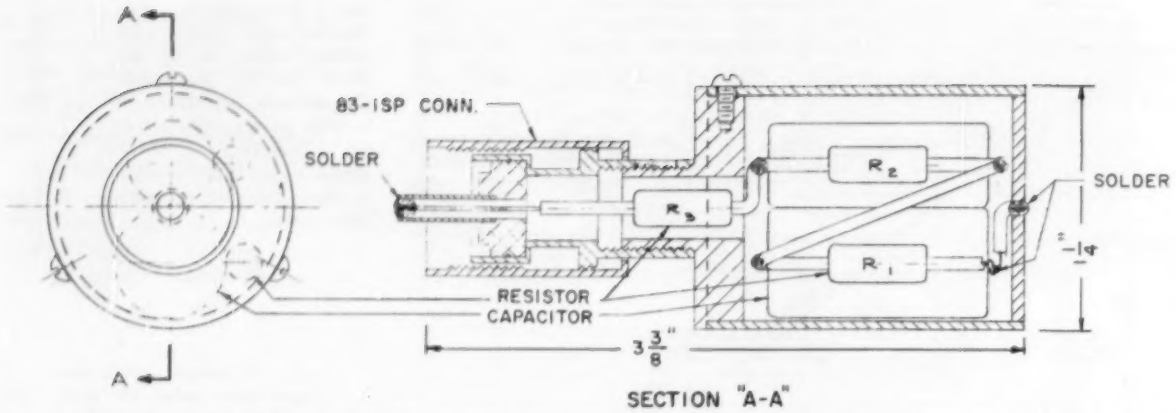


Fig. 4. CBS Types 3A, 3B and 3C Receiving End Complex Terminations showing the small size and convenient method of coupling to standard video coaxial cable fittings.

WE724 cable which has a nominal impedance of 75 ohms, has the following iterative impedances at low video frequencies:

$$\begin{aligned} Z_I \text{ at } 40 \text{ kc} &= 81.1 - j\ 13.8 = 82.2\ \lfloor -9°.6 \\ 15 \text{ kc} &= 86 - j\ 33 = 92.2\ \lfloor -21° \\ 5 \text{ kc} &= 110 - j\ 76 = 133.5\ \lfloor -34°.7 \\ 3 \text{ kc} &= 131 - j\ 106 = 168.2\ \lfloor -39° \\ 1 \text{ kc} &= 213 - j\ 197 = 290\ \lfloor -42°.7 \end{aligned}$$

These values (see Fig. 1) suggest a network consisting of resistors and capacitors. Because of the complex variation with frequency, several components are necessary, and these should be series-parallel combinations.

A direct approach to the calculation of the necessary c's and r's would be to set up a number of simultaneous equations, each being equal to the real and imaginary value of the iterative impedance at each of several frequencies. Figure 2 shows a possible five element network. R_3 must be equal to the iterative impedance at frequencies above about 1 mc, since the reactances of C_2 and C_1 should become negligibly small at the higher video frequencies. The impedance, Z_n, at any frequency (f_n) of this network is:

$$Z_n = R_3 + \frac{R_2}{1 + R_2^2C_2^2\omega_n^2} + \frac{R_1}{1 + R_1^2C_1^2\omega_n^2} - j\left[\frac{R_2^2C_2\omega_n}{1 + R_2^2C_2^2\omega_n^2} + \frac{R_1^2C_1\omega_n}{1 + R_1^2C_1^2\omega_n^2}\right] \quad (3)$$

Each equation for each frequency is a quadratic in reals and imaginaries, hence, the solution could be quite involved.

Another approach and one which is used in this work, is that of successive approximations. A number of groups of c's and r's are calculated at each of several frequencies and the values checked against the necessary impedances for the various frequencies. There is some saving in time by plotting graphs of the real and imaginary values for a number of different c's and r's for each of several frequencies. A sample curve sheet, calculated for 15 kc is shown in Fig. 3. Choosing many successive values of c and r and checking the sums of reals and imaginaries at *several* frequencies leads to a combination which can fit the impedance curve to an accuracy of ±2 ohms down to 10 kc and ±4 ohms down to 2 kc.

Design Calculations

For the coaxial section of a conventional camera cable,[3] the iterative impedance (calculated from r, l and c per foot) has the following values:

$$\begin{aligned} Z_I \text{ at } 1 \text{ mc} &= 53.5 - j\ 0.6 = 53.5\ \lfloor -0°.7 \\ 40 \text{ kc} &= 55.2 - j\ 13.6 = 57\ \lfloor -14° \\ 15 \text{ kc} &= 62.0 - j\ 32 = 69.8\ \lfloor -27°.3 \\ 5 \text{ kc} &= 87.4 - j\ 69 = 111.5\ \lfloor -38° \\ 3 \text{ kc} &= 106 - j\ 94 = 142\ \lfloor -41°.5 \end{aligned} \quad (4)$$

To match this cable for frequencies at and above 1 mc, the termination resistor R_3 (Fig. 2) should be 53.5 ohms. Then at each lower frequency, the real value of impedance contributed by R_2, C_2, R_1 and C_1, must be the real value of Z_I less 53.5 ohms.

Required real value of $R_2C_2R_1C_1$

$$\begin{aligned} \text{at } 40 \text{ kc} &= 1.7 - j\ 13.6 \\ 15 \text{ kc} &= 8.5 - j\ 32 \\ 5 \text{ kc} &= 33.9 - j\ 69 \\ 3 \text{ kc} &= 52.5 - j\ 94 \end{aligned} \quad (5)$$

After trying various values of c and r, it will be found that $R_2 = 330$ ohms, $C_2 = 0.6$ mf, $R_1 = 33$ ohms, and $C_1 = 0.55$ mf give a combination having the following values of impedance, Z_Y:

$$\begin{aligned} Z_Y \text{ at } 40 \text{ kc} &= 1.73 - j\ 13.6 \\ 15 \text{ kc} &= 9.44 - j\ 31 \\ 5 \text{ kc} &= 32.2 - j\ 66 \\ 3 \text{ kc} &= 52 - j\ 94.2 \end{aligned} \quad (6)$$

Adding 53.5 ohms, (R_3), the five element network has:

$$\begin{aligned} Z_T \text{ at } 40 \text{ kc} &= 55.2 - j\ 13.6 = 57\ \lfloor -13°.8 \\ 15 \text{ kc} &= 62.9 - j\ 31 = 70\ \lfloor -26°.3 \\ 5 \text{ kc} &= 85.7 - j\ 66 = 108\ \lfloor -37°.6 \\ 3 \text{ kc} &= 105.5 - j\ 94.2 = 141.5\ \lfloor -41°.7 \end{aligned} \quad (7)$$

The maximum error between (7) and (4) is 3.5 ohms and 1 degree.

After calculation of suitable c and r combinations, experimental units were tested at each of the frequencies, with a "Z-angle" meter. As a further check, the input impedance of a long coaxial cable was measured with the complex termination at the far end. Any appreciable deviation from the first measurements would have indicated a need for modifying the values of c and r. Finally the waveform at the receiving end of the long cable was observed when low-frequency square-wave signals were applied to the sending end. The impedance values checked within ±2 ohms of the calculated values.

Physical Design of Complex Terminations

At the receiving end of the cable, the complex termination must be connected from the inner conductor to the outer sheath, hence, terminal *B* (Fig. 2) is at ground potential. This causes all components except R_3 to be at low potential, so that only R_3 need be spaced from ground. Figure 4 shows the design of the CBS Types 3A, 3B and 3C *receiving* end complex terminations.

At the transmitting end, the high frequency resistor R_3 will usually be an

[3] Howard A. Chinn, *Television Broadcasting*, McGraw-Hill, New York, 1953, p. 587.

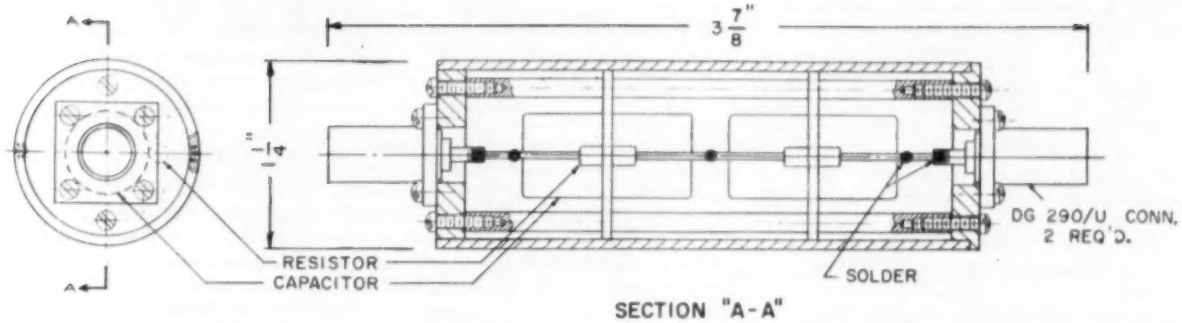


Fig. 5. CBS type 2C Sending End Complex Termination showing the two capacitors (C_2 and C_1) and shunt resistors (R_2 and R_1) mounted on the axis of the cylindrical shield structure to keep the stray capacity per unit length similar to that of the coaxial cable. For the sending end, R_3 (see Fig. 2) is the effective output resistance of the associated video driving amplifier.

integral part of the driving amplifier (see below), and R_2, C_2, R_1, C_1 must be so mounted that their stray capacity to ground *per unit length* of the assembly will be similar to that of the cable. Figure 5 shows the design of the CBS-2C sending end termination. All components should have small tolerances, e.g., $R_3 = \pm 1\%$, R_2 and $C_2 = \pm 2\%$ and R_1 and $C_1 = \pm 5\%$.

Video Amplifier Characteristics

The impedance of the signal source, usually the output stage of a video amplifier, forms part of the *sending* end cable termination. By choosing a video amplifier which has *constant output resistance*, this resistance can be so chosen as to substitute for R_3.

If a high impedance output stage were used, there would be undesirable increase in voltage amplitude with decreasing frequency. Fortunately, video amplifiers having constant output resistance are available, i.e., either anode coupled with shunt resistor to ground, or with inverse feedback and cathode-coupled output.

Amplifier Input Loading

Video amplifiers have shunt capacitance from their input terminal to ground. In parallel with a cable termination, the input capacitance of one amplifier can change the amplitude-frequency response of the circuit above 1 mc to a degree approaching the permissible color signal tolerances. When several amplifiers are "looped-through" at the end of a cable, the error introduced is intolerable, even for ordinary monochrome operation. However, compensation may be provided for each isolation or mixing amplifier by input loading coils.[8] Each coil, with the shunt capacity of the amplifier input, forms a "T" low-pass filter having:

$$R_o = Z_1' \qquad (8)$$

$$L_A = \tfrac{1}{2}R_o^2 C_A \qquad (9)$$

where R_o, Z_1', L_A and C_A are respectively the iterative impedance of the low pass filter, the iterative impedance of the cable at 4 mc, the inductance of each loading coil and the input shunt capacitance of the amplifier. This arrangement results in the amplifier input matching the cable Z_1 impedance but, it should be noted, also introduces a small delay.

The cable termination is connected to the output side of the filter as shown in Fig. 6.

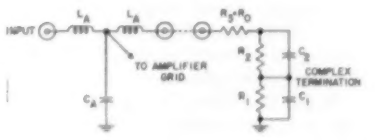


Fig. 6. Schematic showing loading coils L_A added at the input of a video amplifier to compensate for the stray capacitance to ground C_A of the first tube grid circuit. L_A with C_A form a "T" low pass-filter having a characteristic impedance R_o.

[8] D. E. Maxwell first applied this technique in 1949 in order to provide a means of connecting a number of picture monitors to a video source without degrading the performance of the circuit.

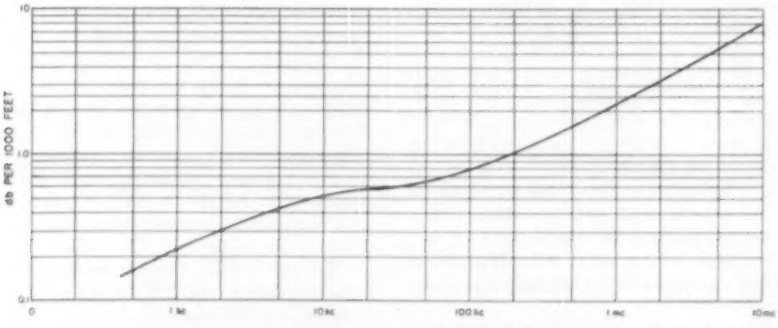


Fig. 7. Attenuation curve of WE724 coaxial cable showing the two discontinuities (at approximately 10 and 70 kc) typical of low-loss coaxial cables.

Cable Equalization

A length of coaxial cable behaves as a complex passive network. It has an amplitude-frequency response with two regions where there is a sharp change in slope, one at about 10 kc and the other at about 70 kc, as shown in the typical

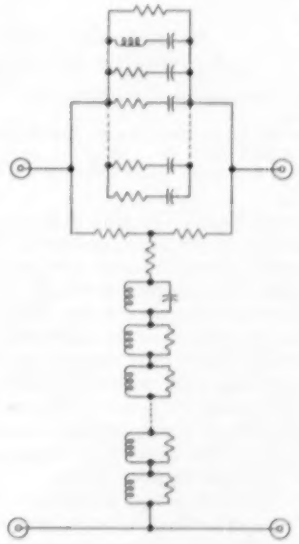


Fig. 8. Complex "Bridged-T" Equalizer showing the many shunt sections of inductance and resistance, with associated series sections of resistance and capacitance required to compensate for the complex variation of attenuation with frequency of coaxial cable.

Table I. Attenuation Equalizer Application.

Signal class	Recommended maximum cable length without equalization	Type of equalizer	Choice of[c] cable lengths, ft	Taps on equalizer
I	24 ft WE 724[a]	WE 323A	50	A-B, C-D
			100	E-F, G-H
			150	J-K, L-M
			200	N-P, R-S
			250	T-U, V-W
			300	X-Y
	42 ft RG-11/U[b]	WE 323A	87	A-B, C-D
			175	E-F, G-H
			261	J-K, L-M
			350	N-P, R-S
			435	T-U, V-W
			520	X-Y
II	200 ft WE 724	WE 323A	200, 250, 300 (see above)	
	350 ft RG-11/U	WE 323A	350, 435, 520 (see above)	
III	Equalizers built into camera or channel amplifiers.			
IV	300 ft WE 724	CBS 6A, 6B[d]	Increments of 300′	
	500 ft RG-11/U	CBS 6A, 6B[d]	Increments of 500′	

Notes:
[a] Where several lengths, each less than 24 ft are in tandem, equalization should be provided for the *total* of such lengths.
[b] But WE 724 cable more stable in attenuation from one lot to another, and with age.
[c] Use tap closest to actual length of cable. If maximum accuracy desired, add extra coiled cable.
[d] See "CBS Television City technical facilities" by H. A. Chinn, R. S. O'Brien, R. B. Monroe and P. E. Fish, Proc. IRE, July 1954, Fig. 24, p. 1089.

Table II. Complex Terminations.[e]

Signal class	Recommended maximum cable length without complex terminations[f]	Cable	Sending end termination	Receiving end termination
I	200 ft	WE 724	CBS 2B	CBS 3B
		RG-11/U	CBS 2A	CBS 3A
II	400 ft	WE 724	CBS 2B	CBS 3B
		RG-11/U	CBS 2A	CBS 3A
III	200 ft	Camera Cable	CBS 2C	CBS 3C
		WE 724	CBS 2B	CBS 3B
		RG-11/U	CBS 2A	CBS 3A
IV	200 ft	WE 724	CBS 2B	CBS 3B
		RG-11/U	CBS 2A	CBS 3A

Notes:
When CBS 2A, 3A, 2B, 3B or 2C, 3C terminations are used, the equalizer must be coupled through an amplifier.
[e] See Figs. 4 and 5.
[f] It is recommended that amplifiers used to feed a cable have constant output resistance.

curve of Fig. 7. The rate of change of resistivity of the inner conductor with frequency is the chief cause of the changes in slope. The complex *terminations* have no losses and therefore do not affect the frequency response of the cable. Correction of the variation of transmission with frequency can be done with additional *equalizing* passive networks which can also compensate for phase (or delay) errors in the cable and thus provide constant delay over the necessary bandwidth.

A suitable equalizer should have constant input and output impedance over a wide range of frequencies, and a loss characteristic with frequency which precisely compensates for the cable attenuation. The design of an equalizer to adequately cover the wide frequency range of the video signal, involves a large number of components. Since the rate of compensation with frequency is an involved function, it is necessary to subdivide the spectrum into various bands and for each band to have a specific group of series and shunt components.[4] The greater the number of bands, with their individual compensation, the smoother is the overall response curve.

Simple π and T networks are unsatisfactory because of the variation of input and output impedance with frequency. Probably the most satisfactory type is the bridged-T, with multiple sections, as shown in Fig. 8.

The construction of an equalizer of this type, to provide compensation within ± 0.1 db from 60 cycles/sec to 6 mc, requires high precision. All coils, resistors and capacitors should have a maximum tolerance of ± 1%. Due to the large number of parts, the physical position of each element must be carefully chosen to prevent undesired inductive or capacitive coupling, which could give a corresponding "notch" in the response curve.

Each multi-element bridged-T, despite the number of components, is suitable only for one particular length of cable. For a studio plant, it is, therefore, usually necessary to have several types.

Recently a commercial video equalizer the WE323A, became available. This unit contains three groups of interconnected multi-element bridged-Ts, with taps to provide adjustment for six lengths of cable, and has a cut-off frequency of 10 mc.

In CBS color television studios, numerous WE323A equalizers are used together with the complex terminations described above. The need for an equalizer and complex termination is determined by the type of signal and the length of the cable. For equalization purposes, video circuits can be broken down into four classifications as follows:

I. Encoded color video to *program circuits;*
II. Encoded color video to *monitors;*
III. Video only (red, green and blue signals); and
IV. Pulse (sync and blanking) distribution.

For class I, an equalizer should be used on any circuit more than 24-ft long, whereas class II circuits do not require equalizers until they become 200 ft long.

Table I indicates the relations between the type of signal, length of cable and type of equalizer, while Table II shows the recommended cable lengths for complex terminations.

Since the WE323A equalizer is designed for a constant 75-ohm termination, it requires isolation through a suitable coupling amplifier when used with a complex termination. The amplifier input terminal is connected to the CBS cable receiving end complex termination, and the output terminal to the equalizer.

Summary

The rigorous requirements of the FCC approved NTSC color television system require great care in equalizing and terminating studio coaxial cables. Methods of doing this have been described in the preceding paragraphs and they have been applied to the CBS color television studios, recently constructed in New York and Hollywood. As a result, transmission tolerances well within the NTSC specifications have been achieved.

The author wishes to acknowledge the encouragement and helpful suggestions offered by Howard A. Chinn, Chief Audio-Video Engineer, and Richard S. O'Brien, both of CBS Television.

[4] P. W. Rounds, "Equalization of video cables," 1954 IRE National Convention Record, Part 2 — Circuit Theory, p. 16.

The Motion-Picture Laboratory

By J. I. CRABTREE

The evolution of the motion-picture processing laboratory is traced from the early days of reel-and-trough processing by Pathé and Gaumont up to the present day of highly efficient and complicated machine handling. During this half-century, many changes have been introduced in order to render the necessary services, to guarantee a uniformly high quality, and to meet economic requirements. In the early operations, processing was controlled largely by visual judgment. When photographic sound recording was introduced, sensitometric and other instrumental controls were adopted and a general refinement of laboratory methods soon followed. The complications of color photography required new techniques and new tools, especially as regards printing machinery. Laboratory work in the service of television is one in which the element of time is emphasized greatly.

During the latter half of the period, a system of motion-picture photography for the amateur involving the making of direct positives by reversal has resulted in the growth of a system of custom processing laboratories. At the same time the ramification of services to professional motion-picture production has been met by the development of new techniques and new functions while a high standard of quality and service has been maintained.

THE BIRTHDAY of the motion-picture laboratory may be considered as coincident with the date of August 1889, when George Eastman sent a supply of motion-picture film to W. K. L. Dickson at the laboratory of Thomas A. Edison in Newark, N.J., for use in his Kinetoscope.[127]

Many previous workers had made pictures of moving objects consisting of a series of photographs on sheets or strips of film or bands of paper; but it would seem reasonable to apply the term "motion-picture" to a laboratory or workroom handling strips of film not less than 50 ft in length.

Dickson has described his method of processing this film as follows[127]: "Attached to this room, which was about 18 by 20 ft in size, were two darkrooms — one for punching, trimming, joining the films, and printing the positives; the other for developing, fixing, washing, and 'glycerining'* the films. These operations were done by using large, black, enameled drums adjustably suspended at each end when immersed in long, shallow troughs [Fig. 1].

"The films were spirally wound around these drums and the ends clamped to hold the film in place. When deemed to be thoroughly developed, the drum was carried to a similar trough to revolve in water coming from a spray over the length of the film or drum. The used water was carried away by an overflow from the trough. The film was then carried to the fixing trough and back to the washing arrangement, thence to the glycerine trough, and dried before a fan while revolving on the motor-driven drum.

"As to our method of printing negatives, I had a large 8- or 10-inch sprocketed drum made, geared to run slowly, over which the films came in contact, the unexposed film being under the negative and the pins engaging both films. A small pea-lamp and reflector were placed above the negative. A square of ground glass was interposed between the light and the film, and the light was regulated by a small slide resistance to give the right exposure. Two spools on each side were used, geared to pick up the

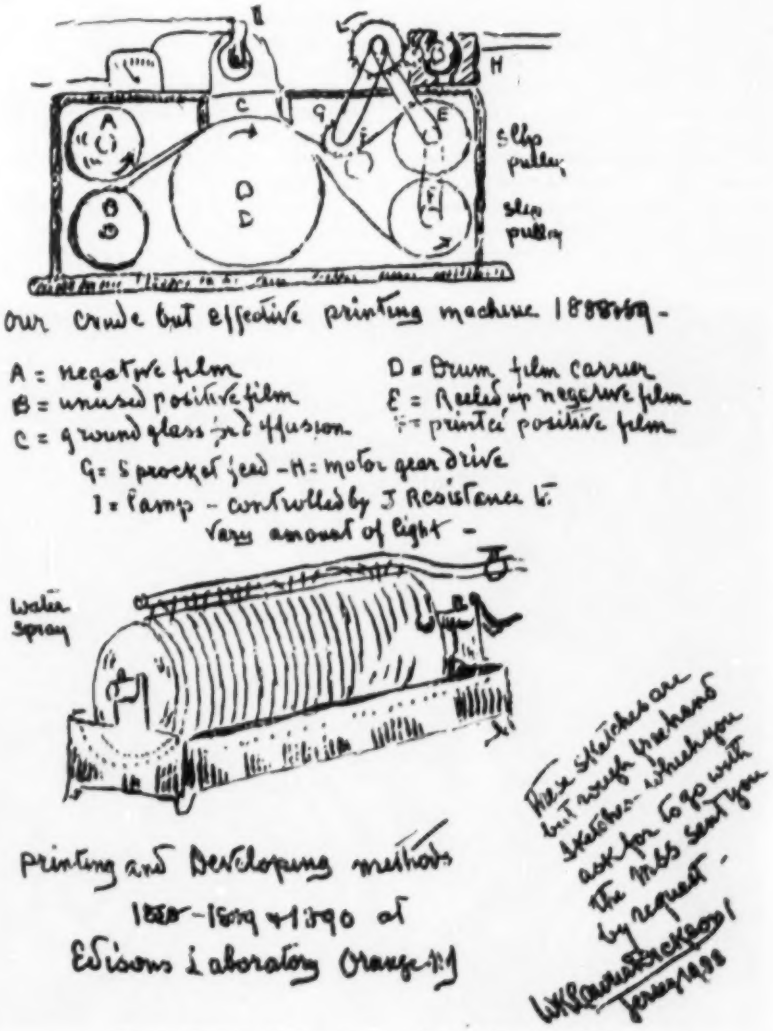

H
slip pulley
slip pulley
Our crude but effective printing machine 1888-89 -
A = negative film
B = unused positive film
C = ground glass + diffusion
D = Drum film carrier
E = Reeled up negative film
F = printed positive film
G = Sprocket feed - H = motor gear drive
I = Lamp - controlled by J Resistance to vary amount of light -
water spray
printing and Developing methods
1888-1889 + 1890 at
Edisons Laboratory Orange NJ
These sketches are but rough freehand sketches - should you ask for to go with the MS sent you by request -
W K L Dickson
Jersey 1928

Fig. 1. W. K. L. Dickson's processing equipment (1888–89).

Communication No. 1668 from the Kodak Research Laboratories, presented on May 6, 1954, at the Society's Convention at Washington, D.C., by J. I. Crabtree, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received on July 12, 1954.)

* A bath of glycerine and water, used to render the film more flexible.

Fig. 2. The Robert W. Paul Printer (1895).

negative and positive films." Thus the principles of "spray impingement" and printing over the surface of a drum were born at an early age.

In the year 1895, L. Lumière gave a public showing of motion pictures with film prepared from "base" obtained from the New York Celluloid Company "which we coated with a sensitive emulsion in our machines and made into perforated rolls" and which, presumably, was processed in the same manner as by Dickson.[121]

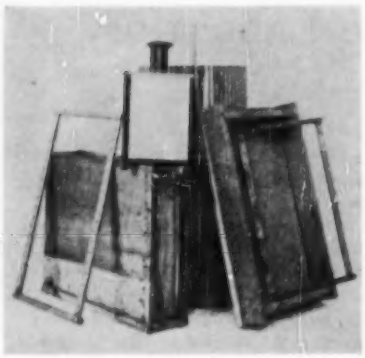


Fig. 3. Paul's Laboratory Outfit (1895).

In the same year (1895), Robert W. Paul in England had manufactured and distributed several duplicates of the Kinetoscope which was not patented in England and, being unable to obtain film subjects from Edison, built a studio and processing laboratory. To quote his own words: "In Birt Acres I found a photographer willing to take up the photography and processing, provided I could supply him with the necessary plant, which I did early in 1895.[120] For perforating the film I made, for use in an ordinary fly-press, a set of punches, 32 in number, made to the Edison gauge and fitted with pilot pins.

"Our printer [Fig. 2] was of the rotary type, consisting merely of a sprocket over which the positive and negative films passed together, behind a narrow slot illuminated by a gas jet. The sprocket was turned by hand at a speed judged by the operator, who inspected the negative as it travelled past a beam of red light. For development, a 40-ft. length of film was wound upon a birch frame with spacing pegs [Fig. 3]. Horizontal or vertical troughs held the solutions and washing water. At first drying was done in festoons, but a little later on light wooden drums. In 1899 a laboratory was erected adjacent to the studio having a capacity for processing up to 8000 feet of film per day." Thus was born the rack-and-tank system (Fig. 4).

Other film producers in England of this period included G. A. Smith, Charles Urban, J. Williamson, A. C. Bromhead and C. Hepworth. Hepworth has described some of his experiences before the British Kinematograph Society.[123] He writes: "My first effort was to photograph the boat race — it must have been the one of 1898, I think — and I took the negative to Wrench's place in Gray's Inn Road to develop on a pin-frame. With the arrogance of youth and the experience of one fifty-foot film behind me I then said that that was not the proper way to develop a continuous strip like a cinematograph film and that it ought to be developed continuously in a machine. So I set to work and made, and afterwards patented, an automatic machine [Fig. 5] in which the film was drawn through a succession of troughs in which it was developed, rinsed, fixed, and washed. Afterwards a printer and a perforator were added to the same machine so that

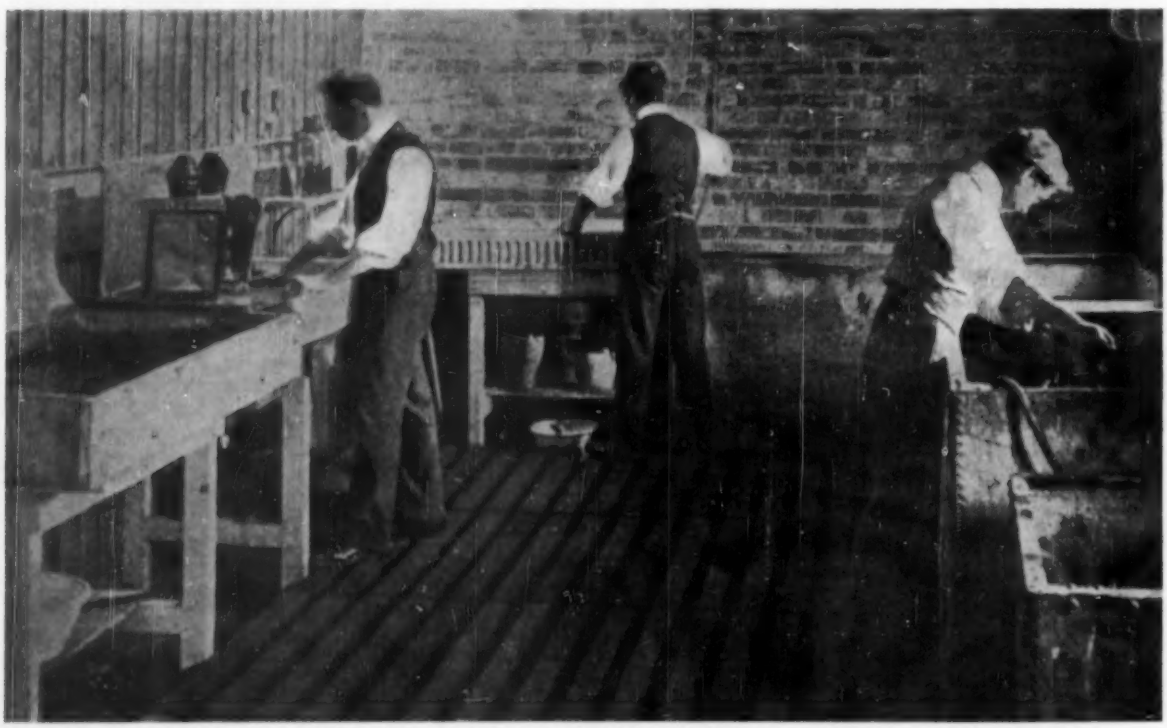


Fig. 4. Paul's Laboratory (1899). (Reproduced from *Moving Pictures* by F. A. Talbot, Lippincott, Philadelphia, 1923.)

we fed the unperforated film, just as it came from the maker, in at one end and it came out a finished print at the other. That was in 1898. In the tiny scullery we installed a vertical gas-engine, direct-coupled to a dynamo. It was just about as noisy as the average road-drill. We always had our meals in the same room. The automatic developing and printing machine was brought from Warwick Court and set up in the drawing-room. The best bedroom became the drying room, where the films were hung in festoons from wires stretched across it; the other bedroom served a similar purpose. The bathroom was the cutting-room and the front sitting-room was the office. My own patent ran out years before the rest of the trade began to feel the need of automatic developing, but it lasted me the whole of my film life, and I still have the consolation of knowing it was the first in the world."

In the same periodical, A. C. Bromhead[125] states: "At that time practically all film producers perforated their own films in their own laboratories. The types of perforator used were chiefly rotary. Laboratories recovered quite a sum by the sale of their punchings or perforations in the residue market. The perforators referred to were chiefly made by Wrench & Prestwich. In the result, perforations varied very widely, because the teeth wore smaller, the matrixes wore larger, and the perforation holes became ragged and irregular, causing unsteadiness of projection. It was really a great boon to the trade when Eastman and Pathé began to supply their stock perforated to an accurate gauge by an instrument of precision."

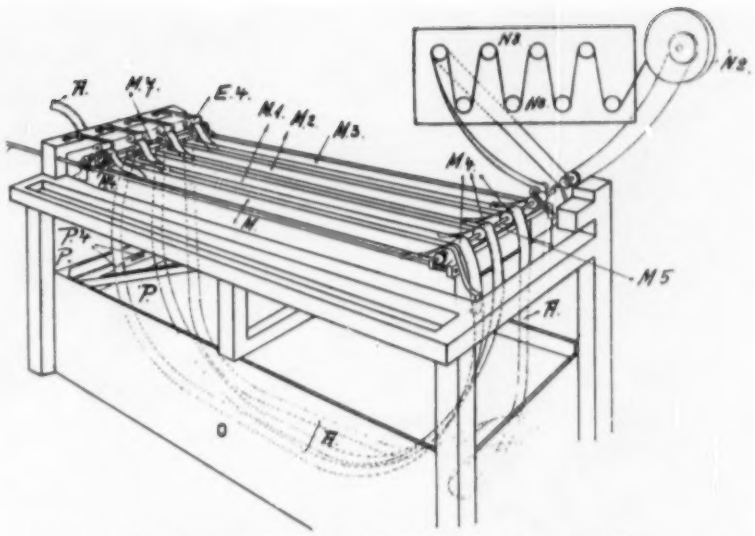


Fig. 5. The Hepworth Processing Machine, British Patent 13,315 (1898).

Simultaneously with technical developments in England, stimulated by the Kinetoscope, many firms in France entered the field of motion-picture production including Lumière, Pathé, Gaumont, George Meliès, Eclair, Lux, George Maurice, Debrie, etc., and during the next two decades they pioneered both in studio work and in the development of processing equipment. Likewise in Germany the motion-picture industry progressed under the leadership of Oskar Messter, Max and Emil Sladanowsky and the firms of Askania, Geyer and Agfa.

The Société des Etablissements Gaumont in 1907 was the first to put into service "batteries" of automatic developing machines.[132] In these, the processing solutions were held in tubes and later in tanks. A single-strip straight-line tank machine was employed by Lobel in 1912 (Fig. 6).

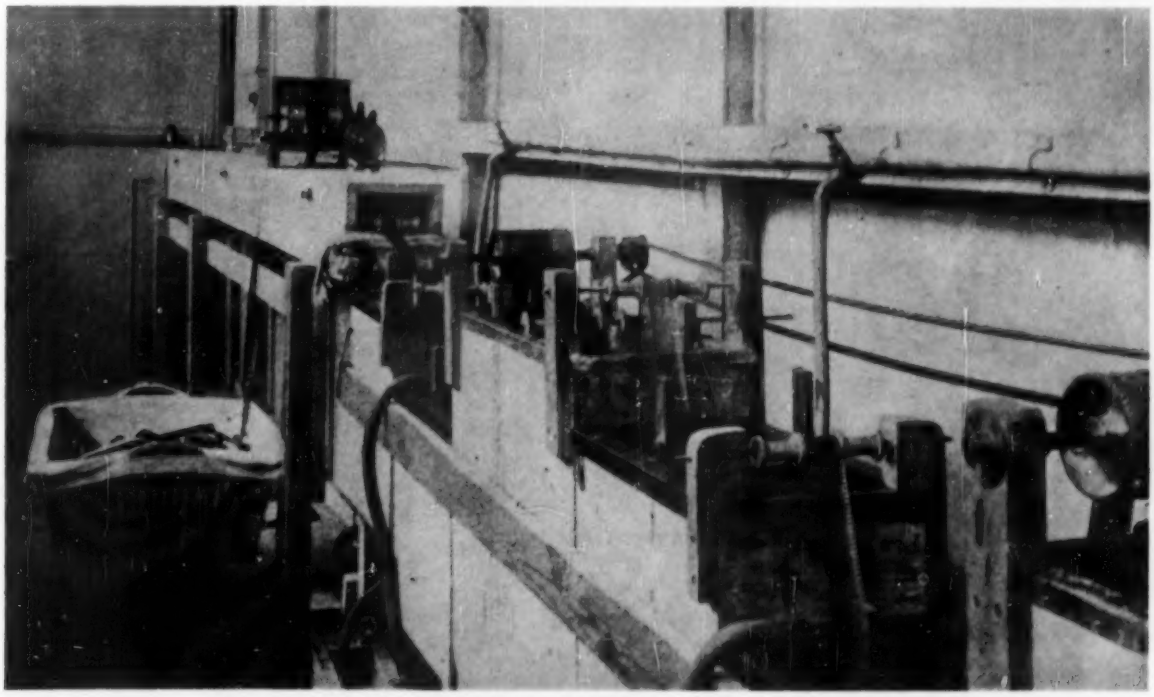


Fig. 6. The Lobel Single-Strip Straight-Line Machine (1912). (Reproduced from *La Technique Cinématographique* by L. Lobel, Dunod et Pinat, Paris, 1912.)

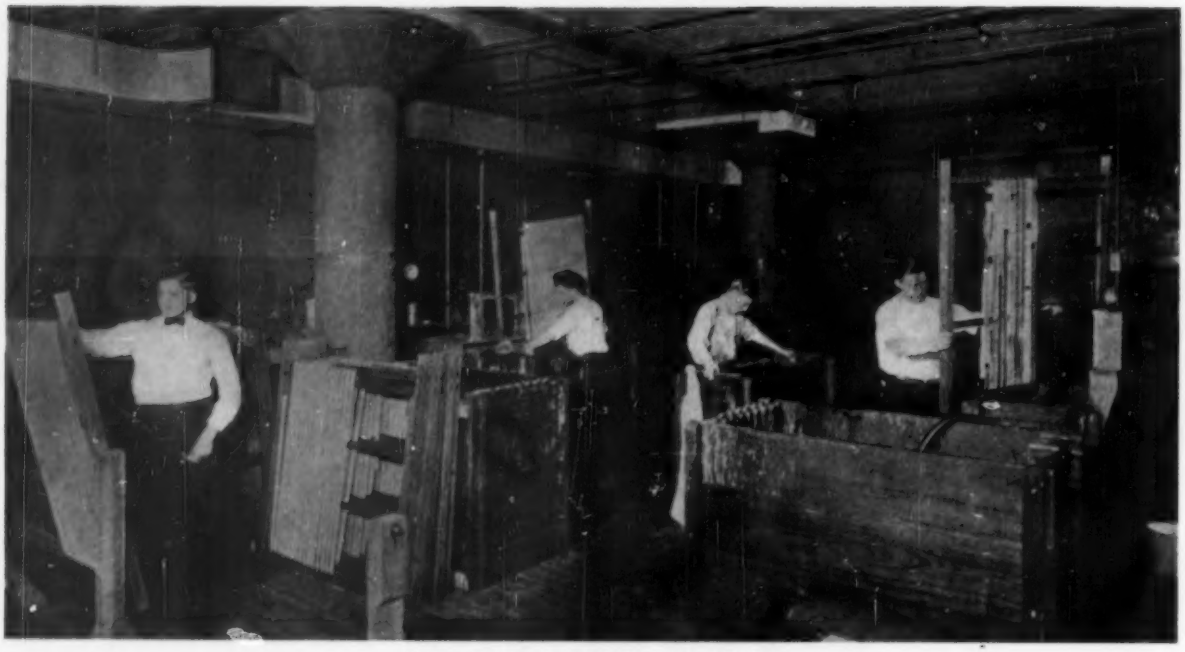


Fig. 7. The rack-and-tank system (1918).

In the United States, the drum-and-trough and rack-and-tank systems largely prevailed (Figs. 7 and 8), but in 1913 Léon Gaumont brought to Rochester, N.Y., a "tube" processing machine of the type illustrated in Fig. 9, in the operation of which I had the privilege of assisting. However, continuous processing machines were not universally adopted until several years later.

In France, the motion-picture laboratory by this time was organized broadly on present-day lines and those in England and the United States soon followed but, in the half-century since that time, many changes have been introduced in order to render the necessary services, to guarantee uniformly high photographic quality, and to meet economic requirements.

Owing to World Wars I and II, motion-picture development was greatly retarded in England, France, Germany and Italy, with the result that during these periods the major technical developments in laboratory processing occurred in the United States but these have been adopted in recent years by most laboratories throughout the world.

It is beyond the scope of this paper to consider the details of laboratory construction and organization which are adequately covered in the literature[127–149];

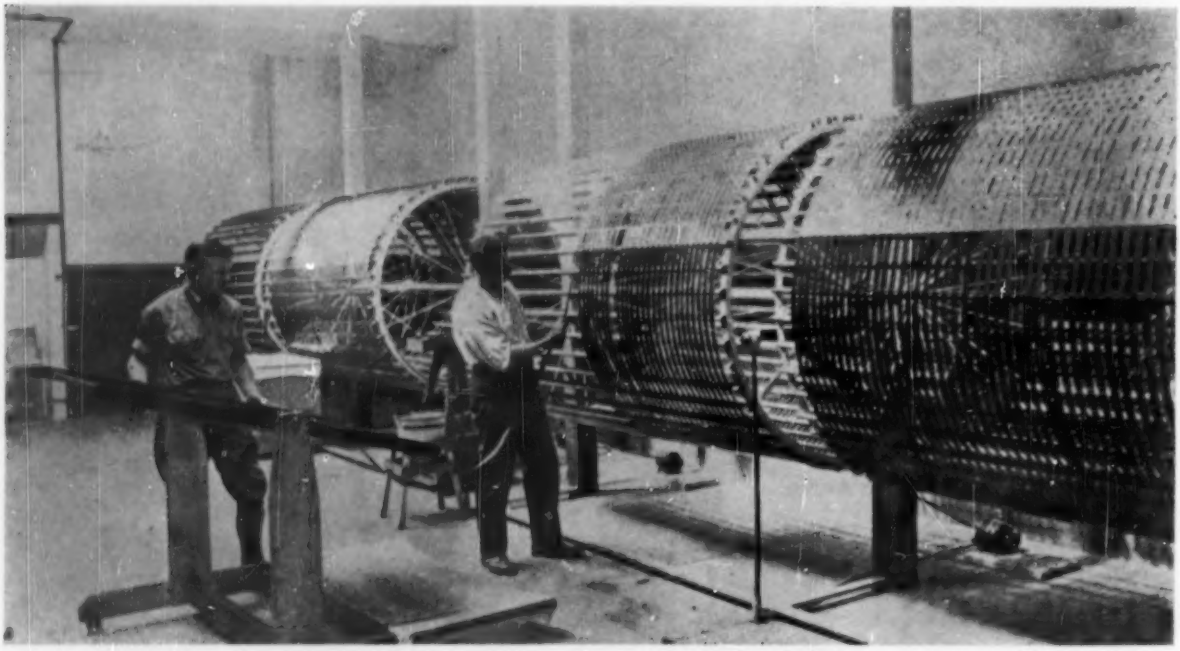


Fig. 8. Transferring film from developing rack to drying drum (1918).

Fig. 9. The Gaumont Tube Machine (about 1913). (Reproduced from *Historique et Développement de la Technique Cinématographique*, Jean Vivié, Editions B.P.I., Paris 1946.)

however at this stage it is perhaps desirable to get a mental picture of the complexity of a modern processing laboratory so as to better evaluate the importance of the various milestones in the path of progress to be discussed later.

The nuclei of the laboratory are the developing and printing rooms containing complex machinery and, to insure their efficient operation, the basement may contain chemical mixing and circulating systems with flow meters (Fig. 10), refrigeration and air-conditioning apparatus, air compressors, electrical generators, water filters and softeners, silver recovery apparatus, a machine shop and a chemical laboratory.

Other departments provide for cleaning the negatives and positives, negative and positive assembly (Fig. 11), splicing, edge-numbering, negative timing, lubrication, editing, projection and storage. Although several types of machines have been devised for applying cleaning liquids and buffing the film[39] in order to avoid possible damage to negatives, many laboratories still clean their film by first winding it onto a plush-covered drum (Fig. 12).

We shall now consider the outstanding developments appertaining to processing laboratories which have occurred during the past half-century and which have been responsible for present high standards in photographic quality and efficiency. These developments may be tabulated as (a) functional milestones and (b) technical milestones.

(a) Functional Milestones

(1) Emergence of the laboratory as a separate organization to produce rush or daily prints and release prints. This occurred about 1900 when the laboratory work was no longer done by the cameraman and his helper.

(2) Additional functions beyond those of developing negatives and printing and developing positives were added in stages, namely, special printing, dissolves, dupes, tinting and toning, titles, reduction prints, "blow-ups," etc.

(3) Entry of the release print laboratory as separate from the studio laboratory.

(4) Establishment of special service laboratories such as for "process work."

(5) Specialist color laboratories: Technicolor, Cinecolor, and others.

(6) Specially equipped newsreel laboratories.

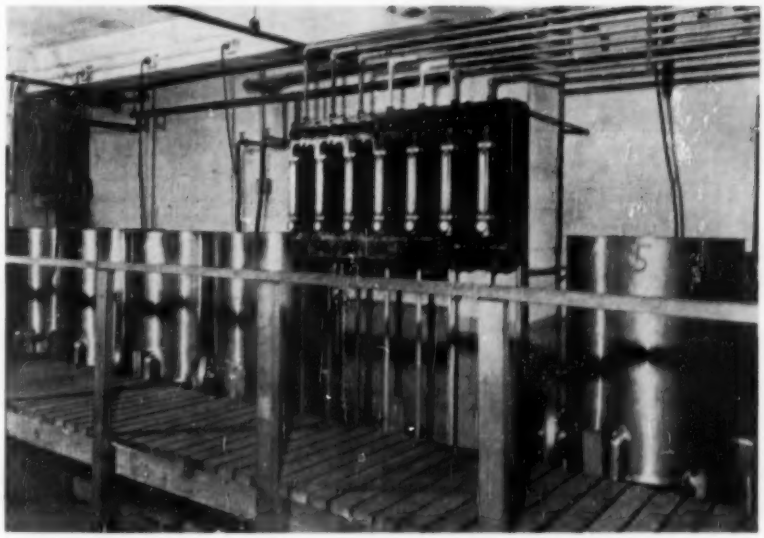


Fig. 10. Chemical mixing room with flow meters. Pathé Laboratories, Inc., New York, N.Y., 1953.

Fig. 11. 35mm and 16mm assembly. Pathé Laboratories, Inc., New York, N.Y., 1953.

Fig. 12. In order to avoid possible damage to negatives, many laboratories clean the base side by first winding on a plush-covered drum. Consolidated Film Industries, Hollywood, Calif., 1953.

(7) Sound production and printing as a laboratory function (1928).

(8) Refined chemical, mechanical and sensitometric control functions brought about largely by (7) (1930).

(9) Amateur service laboratories for reversal of originals and later for making duplicate positives. (This occurred about the same time as (4) and (5).)

(10) Color work in the nonspecialist laboratories (1950).

(11) Rapid and specialized work for the TV industry. This involved quicker service and prints with less than normal density and contrast.

(12) Miscellaneous work, including sound striping, electrical printing of sound and anamorphic printing.

(b) Technical Milestones

With regard to outstanding developments which have contributed to progress in laboratory processing, the following milestones are merely the opinion of one person who has been intimately associated with processing laboratories for over forty years. However, there are undoubtedly errors in precise chronology because, in many cases, several years elapsed before a new procedure made its impact on laboratories as a whole after its initiation.

1886 The old adage, "there is nothing new under the sun" would appear to apply also to processing machines since, in 1886, British Patent 16,327 was issued to John Urie, Sr., and John Urie, Jr., for a processing machine incorporating most of the elements which were adopted in one form or another in later types of processing machines. The machine employs (1) a constant but adjustable running speed, (2) a light-tight feed-on box, (3) feed-on rollers, (4) rollers which guide the film through the machine, (5) deep processing tanks, (6) agitation and uniform distribution of processing solutions, (7) regulation of treatment time by number and lengths of film loops, (8) auxiliary drive rollers, (9) replenisher system and constant liquid level of solutions, (10) storage tanks for collecting overflow, (11) recirculation of processing solutions, (12) means for relieving film tension and taking up of film slack and (13) portable racks which could be raised and lowered in the baths. However, no mention is made either of a drier or reserve elevator.

1898 So far as is known, the first machine actually used for processing motion-picture film is that of C. Hep-

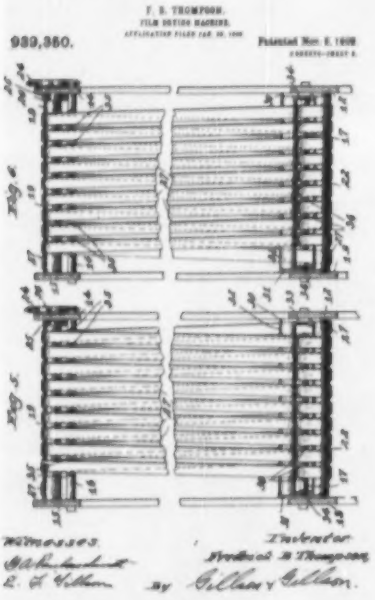


Fig. 13. The F. B. Thompson Film Drying Machine, with helical rack (1909).

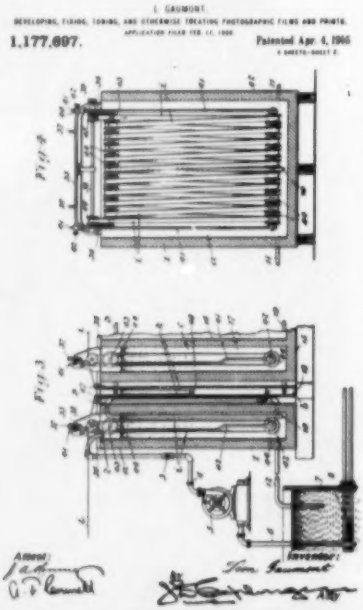


Fig 14. The Gaumont Processing Machine, with spiral path of film travel (1916).

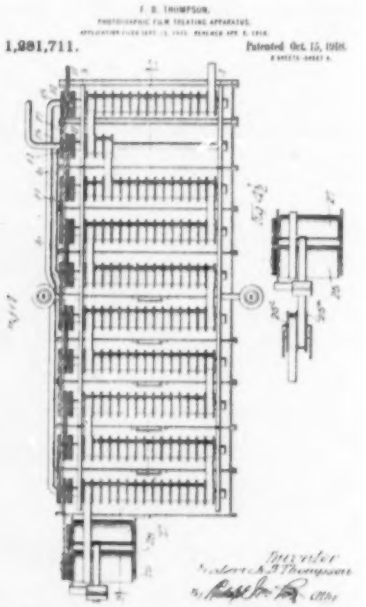


Fig. 15. The F. B. Thompson Full Friction Lower Roller Driven Sprocketless Machine (1918).

worth described in British Patent 13,315 (1898) which consisted of a plurality of long shallow troughs, side by side, having feed sprockets at each end (Fig. 5).

The complete system included a perforator, and a printer from which the film was fed into the first trough over a movable rod which controlled the time of immersion. After passing through the various troughs in succession, the film was fed to a drier and rewind spool. Some years later, H. V. Lawley replaced this principle with a system of long vertical tubes which overcame the excessive aerial oxidation of the developer in the Hepworth troughs.

1907 Installation of "batteries" of tube processing machines by L. Gaumont, Paris.[133]

1909 In U.S. Patent 939,350, F. B. Thompson described a film-drying machine with helical rack, the top and bottom rollers being driven by a chain-and-sprocket combination (Fig. 13).

1913 Installation of a Gaumont tube machine for positive film at Kodak Park, Rochester, N.Y. In this year the first experimental lengths of panchromatic negative motion-picture film were made and processed by the reel-and-trough system at Kodak Park.

1916 United States Patent 1,177,697 (1916) was issued to Leon Gaumont for a motion-picture processor having a plurality of tanks in which upper and lower crowned rollers rotating on shafts afforded a helical path of travel for the film (Fig. 14). This fundamental idea has been adopted in many of the modern processing machines. An accompanying patent (U.S. 1,209,096, 1916) by Gaumont described a drier with means for spiral travel of the film, a safety loop between the tanks and drier for protection against breakage, and an alarm system.

1918 United States Patent 1,260,595 was issued to F. B. Thompson for a processing system having a helical path of rollers of varying diameter to compensate for shrinkage during drying. United States Patent 1,281,711, also issued to F. B. Thompson (Fig. 15), described a full-friction, lower roller-driven sprocketless machine conveying the film in a spiral path in each tank.

In a later patent, U.S. 1,569,156 (1926), Thompson applied the same spiral path idea to the drier using graded diameter rollers to compensate for shrinkage (Fig. 16).

Table I. Classification of Continuous Processing Machines.

I. Sprocket drive — tube type.
One loop between every two sprockets. Loop is weighted.

II. Sprocket drive — multiple idle loop.
Several loops between every two sprockets, movable lower shaft or fixed lower shaft with one lower loop weighted.

III. Sprocket on rack shaft — floating lower shaft idle.
- (a) Sprocket at second position on upper driven shaft to provide 180° wrap. May give pitch trouble with large sprockets.
- (b) Sprocket at first position to give 90° wrap for less pitch trouble.

IV. Sprocketless (with pacemaker).
- (a) Bottom shaft drive
  1. Graded roller diameter to prevent uneven motion.
  2. Rollers loose but alternates pinned to prevent uneven motion.
  3. Bottom rollers on nondriven shafts. Each roller driven when shortening of loop brings it up against driving drum.
- (b) Top shaft drive
  1. Rollers free except about 30% pinned to shaft. Drive governed by position of lower floating shaft which modifies the drive action of a belt running tangent to driven drum on rack-shaft drive.
  2. As in 1, except drive through throttled turbine on each station.
  3. Upper shaft stationary. Rollers obtaining drive on roller rims from drum above.
- (c) Upper driven shaft carrying some pinned rollers among others graded in diameter.

V. Miscellaneous.
- (a) Rubber pinch roller.
- (b) Small machines in which the film is pulled through a considerable path over idle rollers.
- (c) Horizontal tank machines.
- (d) Roller racks which are continuous-motion but not continuous-path machines.

1920 The above-mentioned principles were incorporated in the "Spoor-Thompson" machine which contained the basic principles of most modern processors. Table I lists the various schemes for driving the film in processing machines in present-day laboratories. By eliminating sprockets, potential damage to the film, such as sprocket-hole tears, has been eliminated, unperforated film can be developed with equal facility, and a high speed of film travel in excess of 200 fpm has been made possible.

In the intervening years, many engineers have contributed to the perfecting of the modern processing machine in addition to Gaumont and Thompson, including DeMoos, Hubbard, Chanier, Tronolone, Sentou and Jacquet, Wescott, the Carleton Brothers, Hunter, Gage,

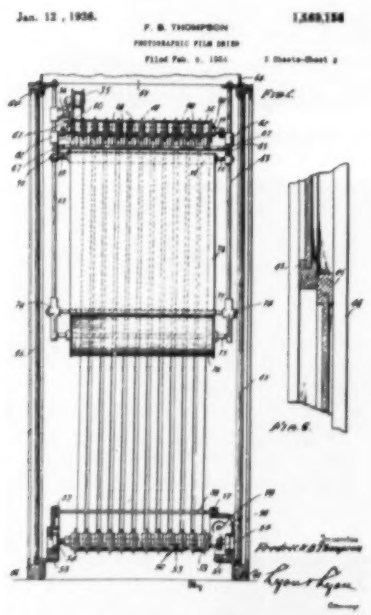


Fig. 16. The F. B. Thompson Film Drier, using graded diameter rollers to compensate for shrinkage (1926).

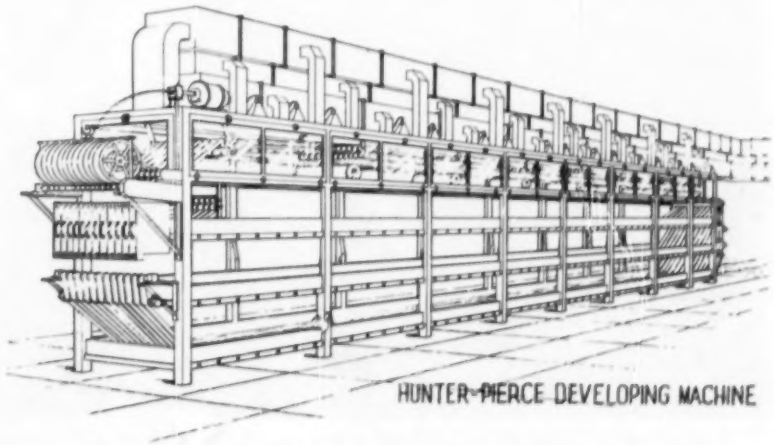


Fig. 17. The Hunter-Pierce Horizontal Tank Machine (1931).

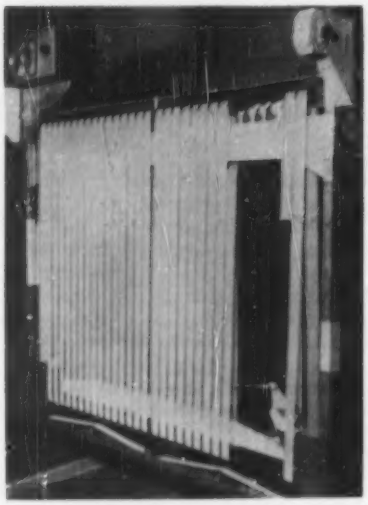


Fig. 18. Roller rack used in rack-and-tank process (1935).

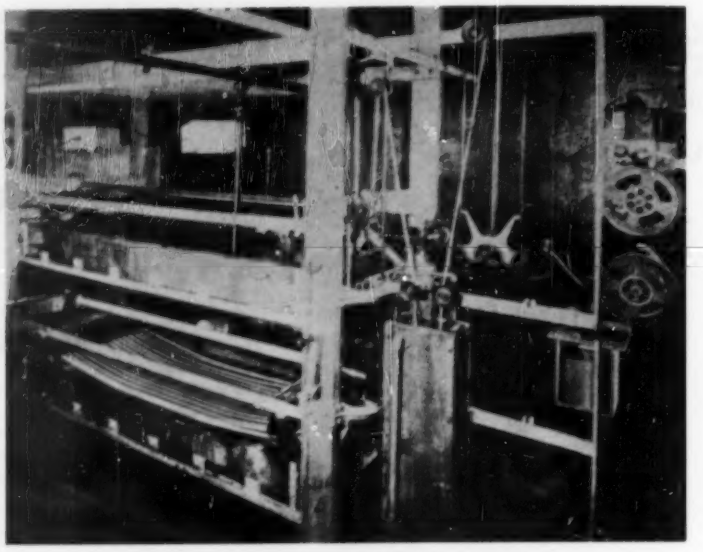


Fig. 19. The Erbograph Machine (1920).

Griffith, Leshing, Nicholaus, Spray, Capstaff, Lootens, Duryea, Tondreau, Bertram, Solow, Miller, Gaski, Vinten, Debrie, Geyer and others.[1]

The Hunter-Pierce machine (Fig. 17) which is typical of Type V (c), consists of three horizontal shallow troughs, one above the other, and accommodates 10 strands of film, each of which is pulled through the entire machine by a single sprocket, although several booster friction drives are desirable. Film enters in the top trough, passes to the second, and then to the lower trough, and up again to the drying box on top at a speed of about 12 fpm.[156]

A typical roller rack for use in the rack-and-tank system, which serves to keep a loop of film moving continuously so as to avoid rack marks, is shown in Fig. 18 and is capable of giving a development uniformity of the same order as that of continuous machines.[92]

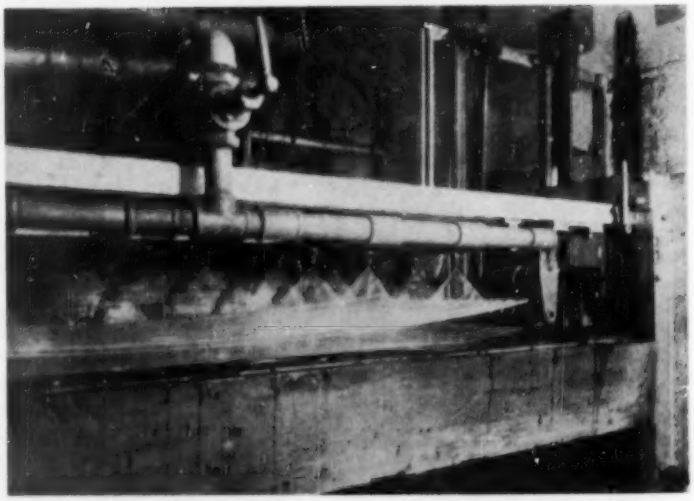


Fig. 20. Spray-washing section of Erbograph Machine (1920).

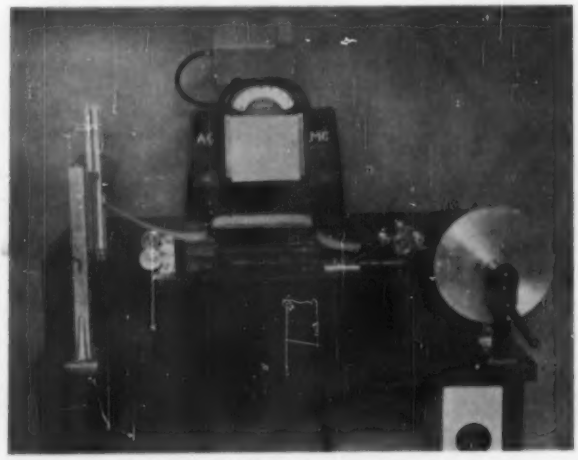


Fig. 21. Scene tester (C. E. Ives and J. I. Crabtree, 1922).

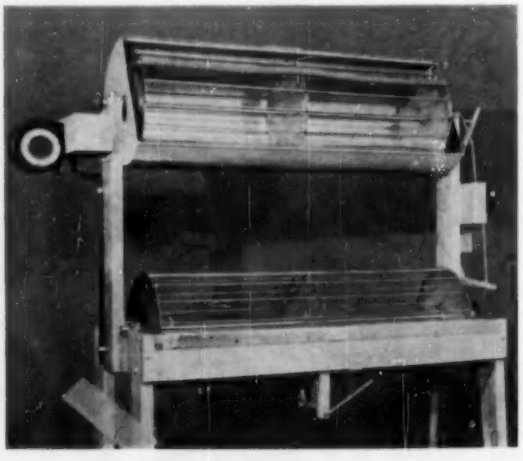


Fig. 22. Double-reel equipment for processing 16mm film (1925).

1920 *Duplitized Film* was supplied by the Eastman Kodak Company for use in two-color subtractive color processes, and many schemes were devised for processing this film, such as floating the film on the surface of the treating liquid or protecting one side by varnishing before immersion and then removing the varnish for the second treatment.

A panchromatic negative film was by now in general use, necessitating a change in darkroom illumination from red to low-level dark green.[222]

1921 The SMPE Committee on Film and Emulsions[222] listed the following existing processing machines: Spoor-Thompson, Duplex, Lawley (England), Pathé, Jaeps (England), Erbograph, Gaumont (Flushing, L.I.), all being tube machines except the Erbograph and the Spoor-Thompson. Some machines used double-toothed sprockets and others sprockets with teeth alternating from one side to the other on successive sprockets.

In the Erbograph machine (Fig. 19), the processing solutions were in troughs superimposed one above the other,[150] the film traveled horizontally and the troughs could be lowered for threading. This machine was one of the first to employ "spray washing" (Fig. 20).

The Lawley machine employed vertical tubes 30 to 40 ft long even for drying, which extended into the third story, but the film tended to adhere to the sides of the tubes causing scratches and breakage.

1922 A simple method of scene testing[251] was devised by printing through a series of neutral densities calibrated in terms of printer steps (Fig. 21), although around 1920 Max Handschiegl in Hollywood manufactured a scene tester employing a stepwise shutter, which varied the time of exposure instead of the light intensity as in the printer. This was later improved by Crabtree, Ives and Tuttle (1930),[248] and the principle was applied, still later, in the Cinex, Reeves, Houston, and Herrnfeld[210] scene testers.

1923 The 16mm reversible Cine-Kodak Film employing a controlled light exposure for the redevelopment stage was born[121] and, in the initial stages, was processed on a reel and later on a double reel illustrated in Fig. 22, the film being transferred to the upper reel for drying.

1926 Cine-Kodak Film was processed commercially on a 7-fpm machine employing removable racks (Fig. 23), one of which is shown suspended from an upper beam. In later machines the speed was increased to 40 fpm.

1927 *Duplicating.* Up to this point, release printing was done from original negatives but, for foreign release, a print on positive stock or a duplicate negative on regular negative stock was supplied which, at best, was of inferior quality. The introduction of Eastman Duplicating Film,[101] which contained a

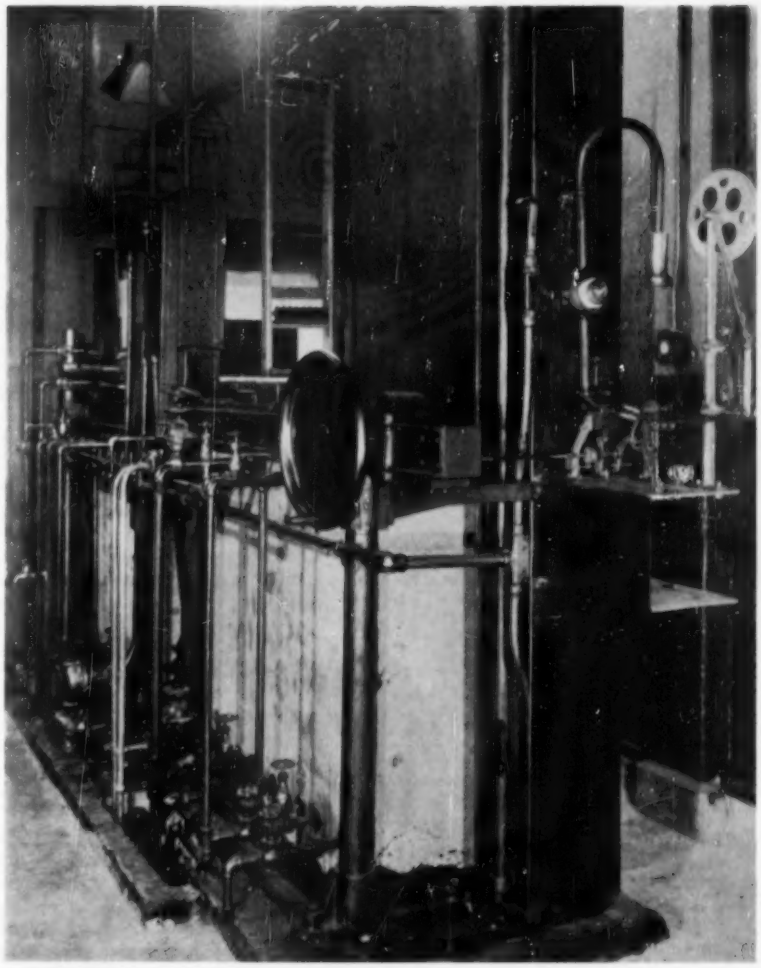


Fig. 23. The First Ciné-Kodak Continuous Processor (1926).

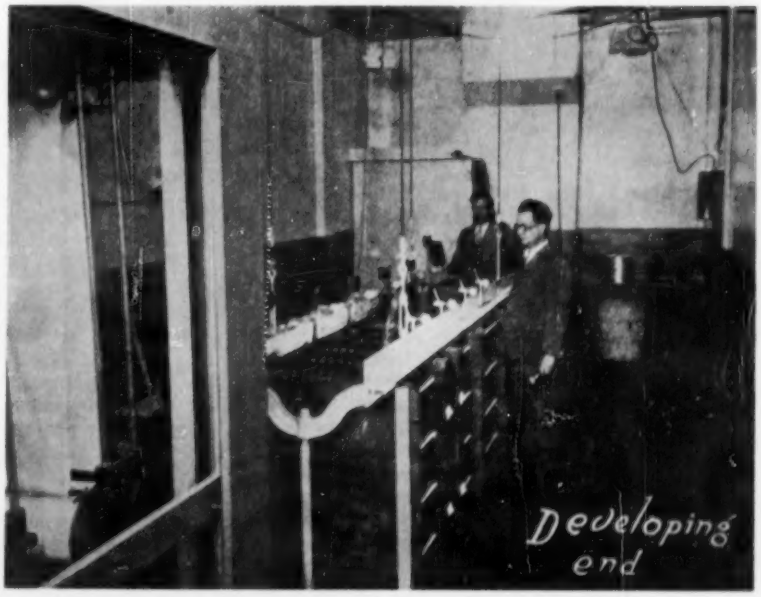


Fig. 24. A machine in which negative film was first developed commercially in the United States (1928).

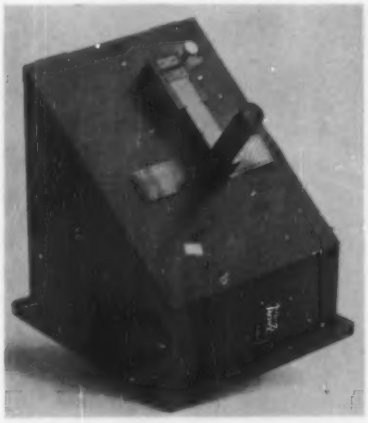


Fig. 25. The Eastman Transmission Densitometer (1930).

yellow dye, permitted contrast control by printing with yellow or violet filters and was employed for making both the master positive and the duplicate negative. At a later date (1937),[105] individual films for making the master positive and the duplicate negative made greater control possible with improved quality and graininess.

In this year, the borax developer, Kodak D-76, was introduced.[100] Hitherto, the only trend in developer substitution had been the use of Metol and hydroquinone in place of pyrogallol or glycin, but the borax developer, with its high content of sulfite and its low pH value, gave finer-grained negatives, better H and D curves, and permitted conveniently longer developing times. Most present-day sound and motion-picture negative developers are derivatives of this formula.

1928 *Machine Development of Negatives.* Up to this time, very few laboratories had dared to develop negative film by machine for fear of damage, although the hope of doing this was expressed in a paper entitled "The Technical Status of the Film Laboratory"[133] in 1928 by L. M. Griffith, of the Paramount Hollywood Laboratory, who stated: "The progress of development technique may ultimately lead to chemically automatic developers capable of yielding the highest quality by simple time-temperature methods and machine processing of negatives will soon be the rule."

In discussing this paper, I stated: ". . .it is apparently up to the cameraman or whoever is responsible for the lighting to so light the set, that with a constant degree of development it will give the negative required. I think it is almost impossible for a man in a darkroom to develop a negative to the correct degree so that it will give a print of the type required. I don't see how he can know unless he knows exactly what each scene is all about. I think that better results will be obtained by standardizing the development. Then if the negative is not right, the lighting is wrong."

Machine development of negative was brought to fruition by C. R. Hunter[150,154] in 1928 who described a modified Spoor-Thompson machine in which he had been successfully developing negative film for over a year (Fig. 24). In discussing this paper, M. S. Leshing (Fox Laboratories) stated: "I was present when the first foot of film went through the negative machine at Universal City and as a 'Doubting Thomas' I sent in over 400 feet of negative. The Universal people didn't know what the subject was or which stock it was. I was agreeably surprised when I saw the results. As a matter of fact, we laboratory men are discouraged when we see this machine working. We 'expert' laboratory men have tried to 'photograph' for the cameramen. I do believe that this is a great step forward in producing uniformity of results."

In August, 1932,[227] the Report of the Progress Committee of the Society stated: "Three of the largest studios in Hollywood have established the practice of developing all negatives to a fixed gamma. The practice at first caused confusion among cameramen, but after becoming familiar with the laboratory technique, they adapted themselves readily to the situation."

Processing of Sound Records. This was an epoch-making year when sound on film became universal although both Fox-Case of Movietone and the General Electric Co. had given exhibitions in 1927 and DeForest in 1923.[122]

Very little was known about the processing of sound records until Engl studied the sensitometric aspects.[264] Sponable and Nicholson of Fox-Case made further sensitometric studies of the flashing-lamp technique[257] with collaboration of the Kodak Research Laboratories, but D. MacKenzie, of the Bell Telephone Laboratories, was largely responsible for working out initially the necessary conditions for processing variable-density sound records.[270]

Since that time a great amount of research has been applied to the determination of the optimum conditions for processing variable-density and variable-

Fig. 26. Film storage cabinets with individual drawers installed in a film vault at Kodak Park, Rochester, N.Y. (1929).

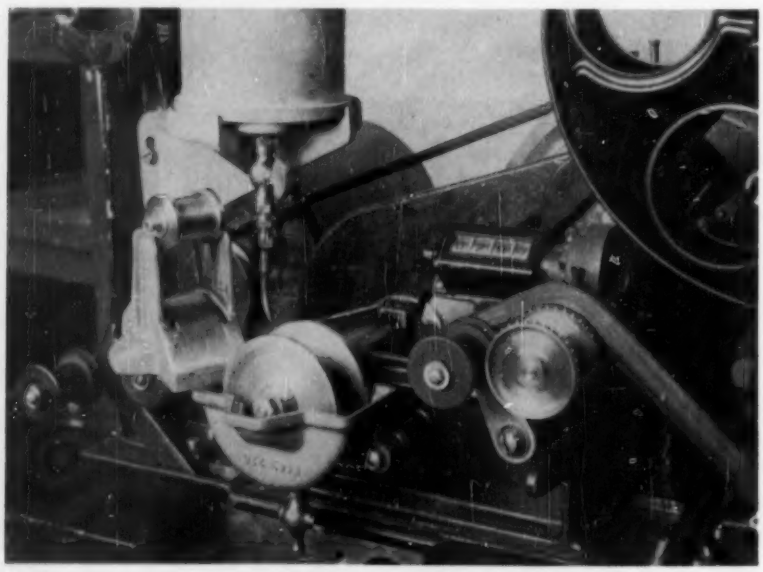


Fig. 27. Eastman Edge-Waxing Machine (1930).

width records by the research departments of the film and apparatus manufacturers and the film studios.

At an early stage it was recognized that sound records should be developed to a fixed degree or "gamma" which necessitated the establishment of sensitometric tests in all studios and laboratories, but the situation in the early days was chaotic until the introduction by Kodak of the Eastman Type IIb Sensitometer[334] and by ERPI of the Western Electric 1100 Densitometer,[73] which instruments greatly facilitated the testing methods. Photoelectric densitometers were later supplied by Eastman Kodak,[85] Ansco,[81] Herrnfeld[84] and others.

After sensitometry had proved its worth in the control of variable-density sound tracks, the next step was to apply it to the control processing of picture negatives and prints.

Previously, negative scenes were developed to different degrees and also the positives to some extent, but now that all positives were to be developed for a fixed time at a given temperature, this tended to compel the cameramen to employ light meters in order to obtain the necessary uniformity from scene to scene.

Provided with a sensitometer and densitometer (Fig. 25) and other refined instrumental aids, the laboratory was able to measure not only variations in the activity of the developer and variations in the degree of uniformity of processing resulting from changes in temperature and degree of agitation, but likewise variations in uniformity of the photographic characteristics of the film emulsions. This had the beneficial effect of compelling the film manufacturers to improve the uniformity of their product, the lack of which it was previously possible to blame on the laboratory.

In the beginning, sound quality of film records was quite inferior by modern standards owing to many causes, including lack of quality-control methods in processing, and it was not until 1935 that a planned system of replenishment of developers was found possible.[90,94] More thorough chemical control by analysis, pH measurement, and replenishment was not realized until 1940.[14–25]

At present (1954), control of laboratory processing of sound tracks is also accomplished by means of intermodulation distortion measurements for variable-density tracks and cross-modulation analyses for variable-area tracks.[276,277] Use of these two techniques has supplemented and, in some instances, replaced laboratory instrument control in the development of sound records.

1929 *Preservation and Storage.* A novel storage cabinet (Fig. 26) for insuring maximum protection to all films stored in a vault and minimum danger from spreading of fire consisted of a series of metal drawers of 1000-ft capacity

Fig. 28. Eastman Electrolytic Silver Recovery Unit (1931).

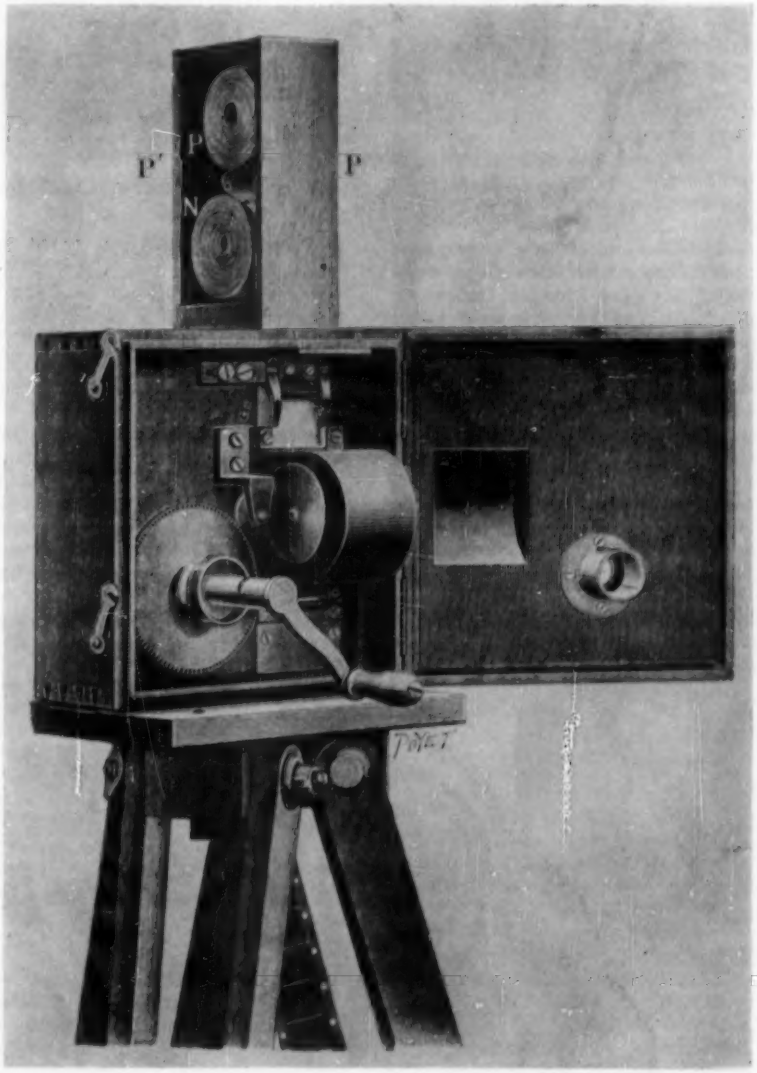


Fig. 29. The original printing machine: the Lumière Camera (1895).

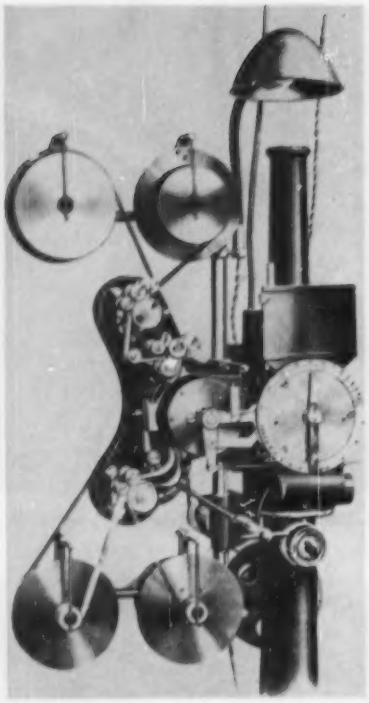


Fig. 30. The Bell & Howell Model D Printer (1912).

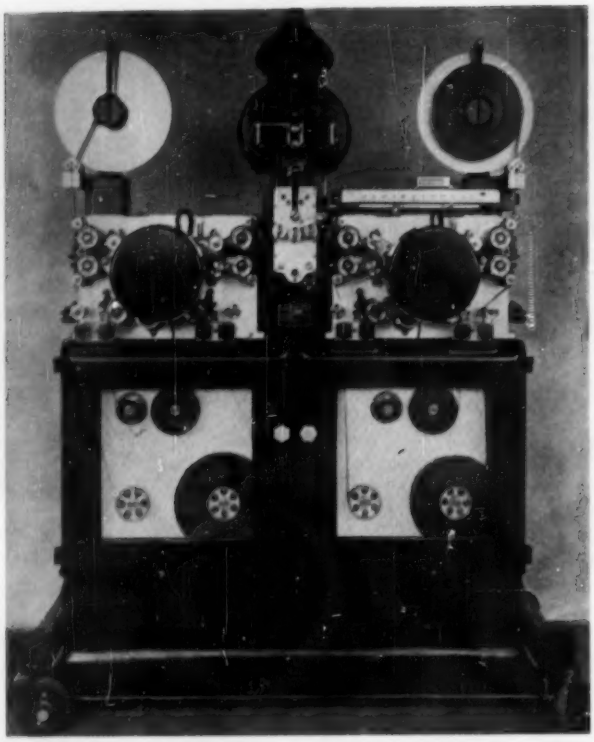


Fig. 31. Bell & Howell Model E Printer and Sound Printer (1932).

contained in fire-resisting wood cabinets.[180] The back end of each drawer was vented into a large flue pipe leading out of the building. Fire tests showed that one roll could be burned up completely without damaging any other rolls in the cabinet.

Most laboratories, however, employed the type of storage vault permitted by the National Board of Fire Underwriters for protection to surroundings, relying on duplicates for insurance of preservation. The universal use of safety film in 1950 tended to simplify the problem of storing future productions.

Apart from the fire hazard, increasing attention was given to the necessity for thorough washing of film[393] to insure its perpetuation, a sensitive method of determining hypo in film was devised[179] and limits of hypo content were established which have since become standard throughout the industry.[180]

1930 *Surface Treatment and Renovation.* After processing and before projection, positive film requires lubrication to prevent offsetting of gelatin in the gate of the projector. In 1922 this was effected by edge-waxing with molten wax[394] and later (1930)[395] with a solution of wax in a readily volatile solvent (Fig. 27); and today many laboratories follow this procedure at the end of the drying cabinet before rewinding.

In order to minimize abrasion of the picture and sound record, a solution of wax was applied to the entire surface of the film, followed by buffing,[287] but this treatment was never universally adopted. Later, in 1941, Talbot[290] described a method of applying a varnish to the emulsion surface of processed film which could be removed and reapplied as the coating became scratched after a period of use.

Throughout the years numerous proprietary preparations have been applied to film with a view to increasing its life and preventing brittleness but none has been sufficiently effective to gain universal adoption.

A scratch-removing process which had some merit consisted in swelling the gelatin coating in a caustic solution and the base side with a suitable solvent, and then drying.[289]

Wide Film. During 1930 there was a great flurry of interest in wide film, various standards being proposed, namely, 70mm for Fox Grandeur, 63mm for "Natural Vision" by Spoor and Berggren, and 56mm for Magnafilm by Del Riccio and LaPorte of Paramount.[123] Special processing machines were devised for each of these dimensions but none has survived beyond the pseudo-commercial stage.

1931 *Electrolytic Silver Recovery.* As a result of the researches of Hickman, Sanford and Weyerts,[288] electrolytic recovery of silver from exhausted fixing baths was initiated in many laboratories. A typical electrolytic unit, shown in Fig. 28, provides for rapid agitation of the solution by paddles operating between the electrodes, thus permitting the use of high current density without sulfurization of the bath. A U.S. Patent (1,866,701) was issued to Garbutt and Ingman in 1932, but filed in 1929, for a method of silver recovery utilizing air agitation of the electrolyte, and this method was adopted in the Hollywood Paramount Laboratory.

For many years previously, laboratories had recovered silver by precipitating it as sulfide and then discarding the bath, although by this method it is possible to re-use the fixing solution after filtration provided an excess of silver ion is maintained during precipitation. Apart from the economy effected by electrolytic recovery, the necessary attendant analyses serve to insure uniform fixation and hardening properties of the fixing bath.

1932 *Automatic Printing.* At this stage, picture prints had been made on step printers such as the Lawley, Williamson, Duplex (flat and curved gate), Vinten, Debrie, Depue, Askania, Geyer, etc., machines and, in the earliest stages, the camera, such as the Lumière,[121] was employed also as a printer (Fig. 29).

By now, the Bell & Howell Model D continuous printer (Fig. 30) and the Duplex step printers were prevalent types throughout the industry. Negative timing was largely by eye and, surprisingly, for black-and-white work, this method is almost universally employed today. Ex-

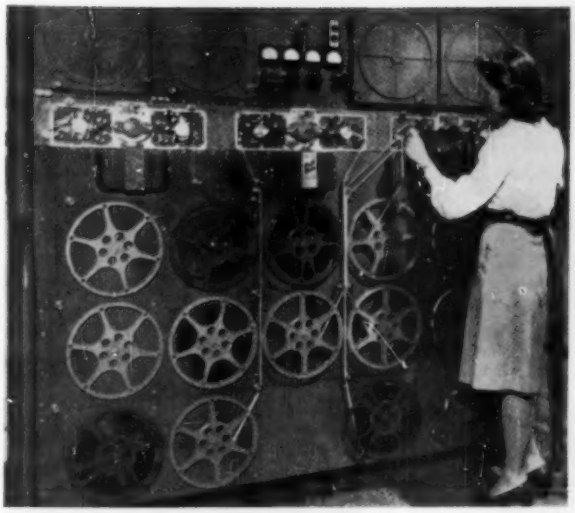


Fig. 32. A modern multihead printer. The Calvin Co., Kansas City, Mo. (1952).

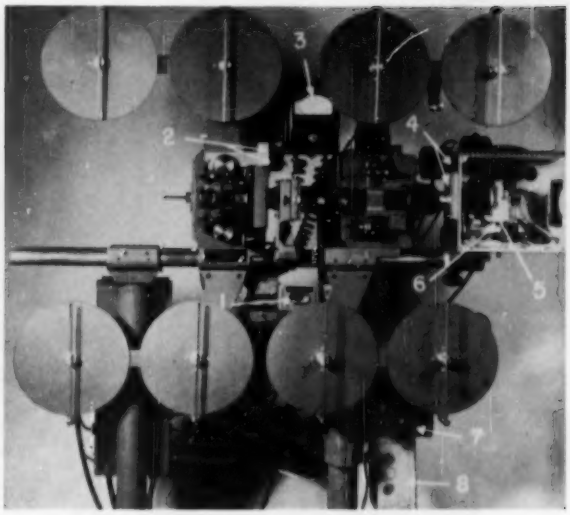


Fig. 33. The Peterson Optical Printer (1952).

posure sequence was effected with the aid of edge notches which activated mechanisms for varying the lamp voltage or the diaphragms in the New York laboratories, although in Hollywood most timing is accomplished by the light test method.

Sound negatives were printed by contact in a separate operation on the Model D printer with a mask in the gate to eliminate the picture area. Optical printers were in the development stage.

With the advent of the Bell & Howell Model E printer (Fig. 31) in 1932, the picture and sound were printed in one operation and by this time an infinite variety of printers were devised by laboratories and manufacturers, each laboratory usually modifying the Bell & Howell Model D or Duplex printer head and using these in tandem or in combination with a soundhead. Rewinding was avoided by making printers reversible or printing from the looped negatives. A multiple-head printer is shown in Fig. 32.[219]

Optical printing was being adopted about this time, making possible either a 1:1 ratio or 16mm:35mm or vice versa, both with picture and with sound. Several optical printers are in common use today, including the Depue, Acme-Dunn, Peterson (Fig. 33), Maurer, Arnold & Richter, Union Tonfilm (Germany), and the RCA and Eastman Model D sound printers.

1935 This was another epoch-making year, being the birthday of the three-color 16mm Kodachrome Process,[42] in which a multilayer film was utilized which could be processed by successive immersion in solutions without recourse to imbibition or other treatments.

In the earlier years, selective development of the emulsion layers was dependent on the differential penetration of the processing solutions but later, in 1938, the film layers were so sensitized that development of each layer could be initiated by exposing the film in succession to cyan and yellow light. A typical processing machine is shown in Fig. 34.

1937 Agfacolor Reversible 35mm Film was made available and Eastman Kodak and Du Pont fine-grain sound-recording films in 1938, which made it feasible to develop variable-density sound negatives in the regular picture negative developers. Eastman Kodak also supplied 32mm film for slitting to 16mm after printing from a tandem negative and processing.

1939 Photoelectric densitometers were rapidly replacing the visual types.[71–85] It is interesting that as early as 1921 W. G. Story, Jr., measured the transmission of photographic images with a photocell and suggested this application to the determination of printing exposure.[211]

1940 Integral printing was in use involving a hookup of printer, processor and projector. The printer and projector ran faster than the processor but elevators were interposed to accommodate the differential speeds. Such a hookup was in full operation in the Fort Lee laboratories of the Consolidated Film Industries in 1934. The current layout in the Consolidated Hollywood laboratories is shown in Fig. 35.

Turbulation. This term is often applied to the extent to which the solutions are removed at the surface of the film during processing and is usually proportional to the degree of agitation or "turbulence" of the liquid.

The importance of agitation in photographic processing has been frequently

Fig. 34. A Kodachrome Continuous Processing Machine (1953).

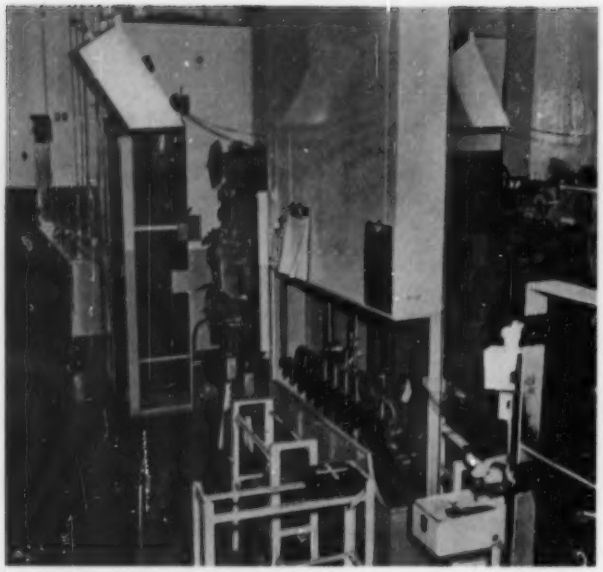


Fig. 35. Illustrating integral printing involving a hookup of printer, processor and projector. Consolidated Film Industries, Hollywood, Calif. (1953).

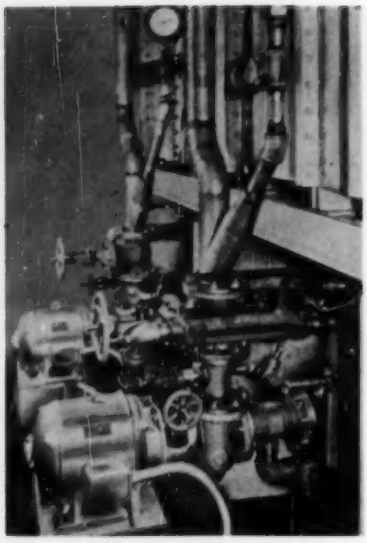


Fig. 36. 400-gpm capacity circulating system for jet agitation in color processing. Pathé Laboratories, Inc., New York, N. Y. (1953).

stressed in the literature but its significance in motion-picture laboratory processing was only fully revealed when attempts were made to improve the quality of sound records. Crabtree, of the Bell Telephone Laboratories,[1,2] was the first to study this subject in detail in relation to variable-density sound records but the first published account of attempts in a commercial laboratory using the Spoor-Thompson type of machine to increase the degree of turbulation in order to decrease "directional effects" or "sprocket-hole modulation" was by Leshing, Ingman and Pier in 1939–1940,[6] although in 1935 Ingman was granted U.S. Patent 1,991,251, which claimed the use of submerged jets for increasing turbulence in processing solutions. The normal degree of agitation resulting from the rapid motion of the film in this type of machine had been only partially effective in preventing the above defects but, by emptying about 75% of the developer in the tank and flowing the developer from the top down the vertical moving strands of film, the "directional effects" were largely eliminated, although this procedure was conducive to aerial oxidation of the solution. This method constitutes an application of the scheme used at the Warner Studios many years ago, the film being developed on a reel. The developer was poured over the reel, across the surface of the film, thus turning the reel in the manner of a water wheel.

In the same year, Capstaff patented a "spray rack" (U.S. 2,169,758) which provided immersed nozzles or spray pipes arranged adjacent to the film loops, and "backing rollers" were provided to maintain the position of the film. This method is currently used in many laboratories, especially for color development. A typical arrangement of the pumps and piping for such a system is shown in Fig. 36.

Other methods of turbulation involve agitation with air or nitrogen.[3]

E. A. Bertram has advised that in 1936, under-surface turbulation and "waterfall" application of developer was employed for negative development in the DeLuxe Laboratories, New York, N.Y.

Likewise at the DeLuxe Laboratories, spray application of all processing solutions was in force for positive 16mm film in 1937 (Fig. 37) while in 1941 complete spray application of all solutions was in use for the development of 35mm negative films (Fig. 38).

An almost unique method for reducing directional effects was that of Davidge (1935),[31] which involved winding the film on a reel with an interleaving apron to separate the convolutions and rotating the reel in the developer solution, baffle plates in the tank serving to force the developer across the film surface. A 1000-ft unit is shown in Fig. 39.

1941 Coating of film with a removable lacquer to prevent abrasion and scratches was initiated.[299]

1942 Printing of sound records with ultraviolet light[271] served to prevent depth penetration of the latent image and image-spreading, giving better resolution.

In 1928 Sandvik and Silberstein[265] demonstrated the improvement in resolving power by the use of ultraviolet radiation but later Oswald and Foster in a series of patents claimed the use of ultraviolet for the recording and reproduction of sound and the printing of motion-picture film (U.S. 1,928,392, 1933; 2,030,760, 1936; 2,055,261, 1936; 2,213,-531, 1940).

1945 Processing procedures for Ansco reversible[41] negative and color positive film were made available to laboratories.

1946 *Rapid Processing.* Although most laboratories employ the ASA standard development temperature of 68F, rapid processing of motion-picture film at temperatures up to 125 F was accomplished[243] by the use of (a) specially hardened emulsions or prehardening baths, (b) elevated temperatures for the developer, fixer and wash water, (c) optimum agitation by spray application of the solutions and wash water, and (d) drying by contact with a heated surface or by jets of air.

In the 35mm machine shown in Fig. 40, the film passes successively through spraying chambers which apply the processing solutions at 130 F, the film being finally air-squeegeed and dried by jets of hot air applied at numerous points as the film passes around the periphery of a "bicycle wheel."

Several adaptations of this machine have been made for television kinescope recording and microcopying (Fig. 41).

Commercially available rapid processors include the General Precision 16mm[167] and the Paramount.[246] The Debrie Aiglonne, while of relatively slow speed, is of novel design and is self-threading.[34]

Construction Materials. With the introduction of continuous processing ma-

chines, it was necessary to employ a variety of corrosion-resisting construction materials more amenable to fabrication to replace the wood, stone, brass, glass, etc., previously employed for rack-and-tank work. Molybdenum stainless steel A.I.S.I. Type 316 was available and since has been extensively employed in modern processors.[51–59] A large number of plastics were also introduced, many of which are suitable for tank linings, bearings, rollers, piping, etc.

1947 Another epoch-making year was 1947, when magnetic recording was tending to replace photographic recording in the studios, thus eliminating the laboratory processing, and by the fall of 1948 was almost generally adopted.[274] However, re-recordings continued to be made photographically.

Magnetic striping of processed and unprocessed film was proposed by Camras.[173]

1949 Du Pont color positive film for printing from three-color separation negatives was issued which employed synthetic binders for the silver halides which were, at the same time, color couplers.[45] Procedures for processing Kodachrome film were made available to laboratories.

Manufacture of nitrate film was discontinued by Kodak and soon after by other manufacturers and so only safety film was supplied. This had the effect of reducing fire hazards in the laboratory and making available construction sites for new laboratories in zoning areas previously forbidden. A fluorescent dye was incorporated in the safety film for identification with ultraviolet light.

1951 Eastman and Ansco color negative and positive films were introduced[47, 48] and rapidly adopted by many laboratories which, for many years, had been anxiously awaiting the availability of a color process which they could handle themselves with a minimum of alteration to their existing equipment.

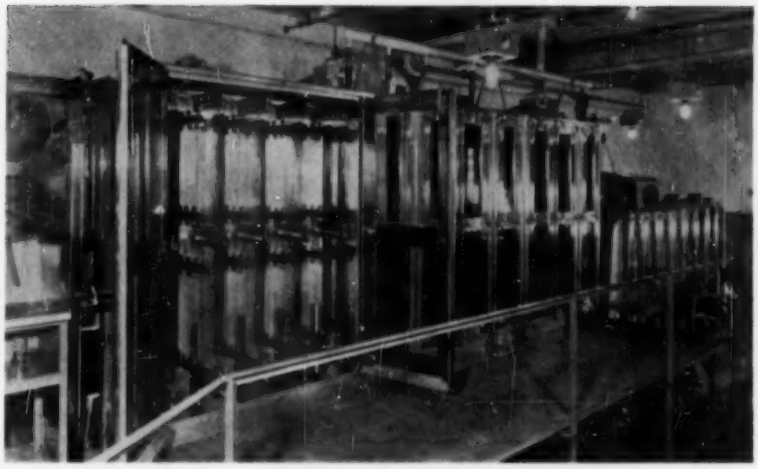


Fig. 37. 16mm spray application machine for positive film. DeLuxe Laboratories, New York, N.Y. (1937).

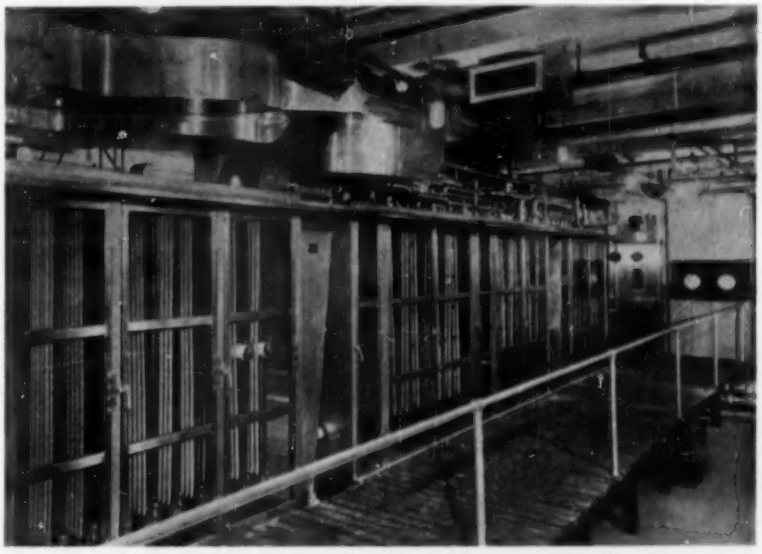


Fig. 38. 35mm spray application machine for positive film. DeLuxe Laboratories, New York, N. Y. (1941).

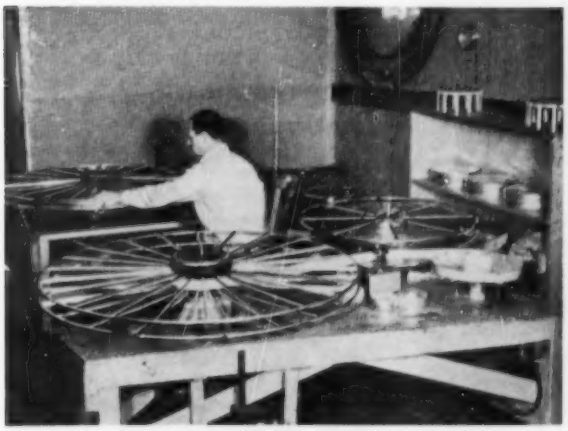


Fig. 39. The Davidge 1000-Ft Developing Reel, which is rotated in the processing solutions (1935).

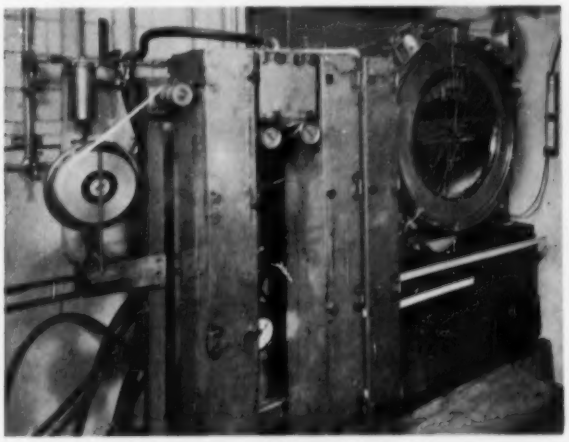


Fig. 40. A machine for rapid processing at 125 F (Ives and Kunz, 1950).

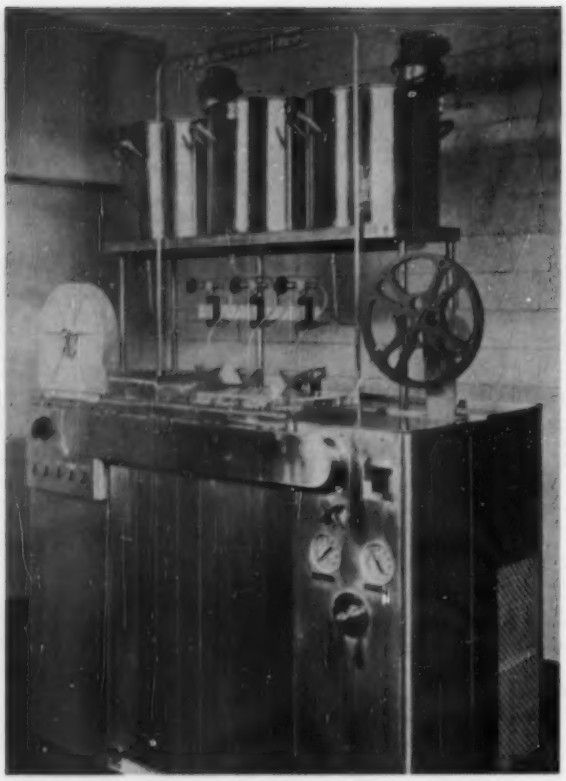


Fig. 41. The Recordak Rapid Processor (1953).

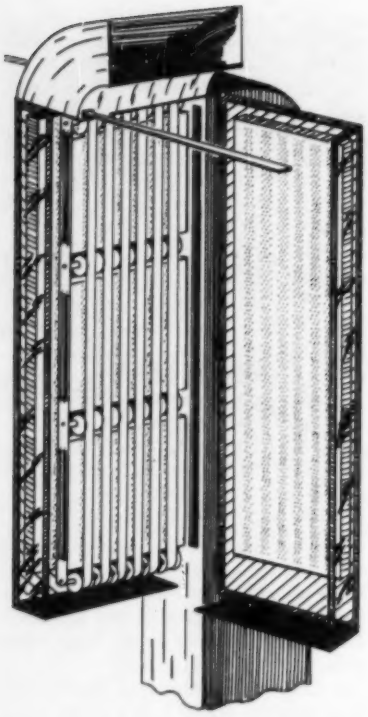


Fig. 42. Illustrating method of rapid drying by impingement of warm air from a large number of air jets (Miller, 1953).

1952 Supplementing color negative and color positive, a color internegative film[49] was introduced for duplication and for use in special-effects work.

With improvements in emulsions, processing solutions and machinery, it was now possible to increase the speed of processing color films from 20 to 40 fpm and later, in 1954, to 60 and as high as 150 fpm in some laboratories. The speed of processing black-and-white positive film in some cases exceeded 200 fpm.

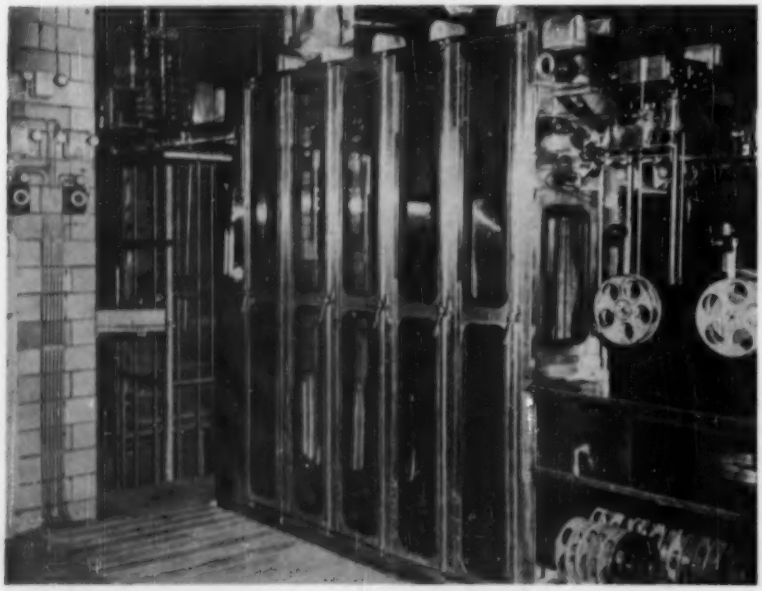


Fig. 43. The complete drying section of the 150-ft/min machine (35mm) at the DeLuxe Laboratories, New York, N.Y. (1954). It is only 5 ft in width.

Rapid drying of film[37] was being accomplished by impingement of warm air (125 to 210 F) through a large number of small orifices in a plenum placed in close proximity to the film, as illustrated diagrammatically in Fig. 42. In 1953 the general trend was toward this type of drier construction and the adoption of higher processing temperatures to insure more rapid production.

Figure 43 illustrates the complete drying section of the 150-fpm machine at the DeLuxe Laboratories, New York, N.Y. Eastman Color Positive Film (35mm) is dried in 1 min 45 sec with air at 155 F (October 1953).

1953 Magnetic striping of 16mm and 35mm films was in progress in many laboratories either by disk application of a slurry of magnetic material (Fig. 44)[178] or by laminating a strip of magnetic tape.

Electrolytic regeneration of a rapid developer containing vanadium salts was accomplished by means of electrolysis[99] but it is doubtful if this scheme will replace the existing developing solutions in the immediate future.

Current practice (1953) in the Precision Film Laboratories, New York, N.Y., for optimum quality in 16mm prints, is to print picture and sound separately, the picture on the (step) contact, or reduction printers, and the sound on 1:1 optical printers or electronically from

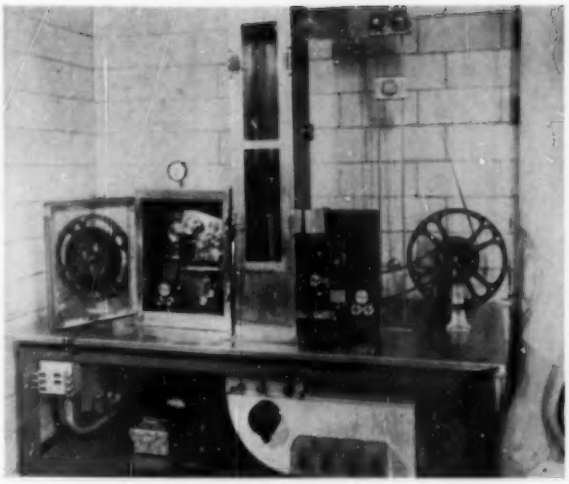


Fig. 44. A magnetic striping machine (Dedell, 1953).

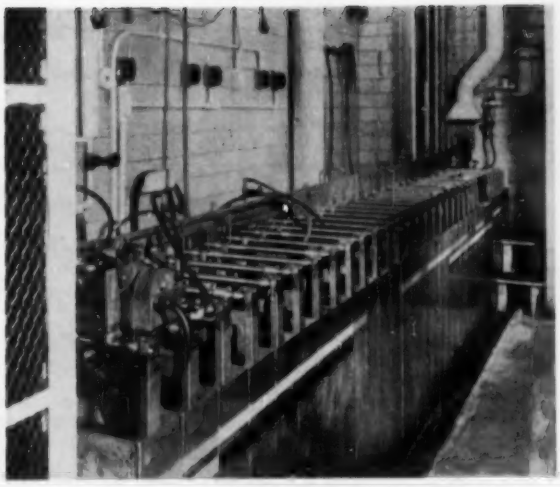


Fig. 45. Modern color processing machine (Eastman Kodak, 1953).

a magnetic track distributed to several optical printers.

The Impact of Color on the Laboratory. Until the advent of multilayer subtractive color films and their general availability, color photography had little effect on the majority of service laboratories since most processes such as Technicolor, Gaumont, Keller-Dorian, Prizma and Cinecolor were operated by individual laboratories, each system requiring specific treatment.

The Consolidated Film Industries operated the Magnacolor Process which was later superseded by the Trucolor Process. Magnacolor was similar to Cinecolor, being a toning process using Duplitized Positive. Trucolor was a color development process utilizing color couplers incorporated in both sides of a Duplitized Positive.

Multilayer films can be handled on processing machines essentially similar to those employed for black-and-white films but require more tanks, more complicated solutions, auxiliary tanks for processing the sound track and, in printing, it is necessary to control both the hue and intensity of the light source. A typical processing machine is shown in Fig. 45.

In view of the complexity of the chemical and optical reactions involved, rigid control methods must have even greater precision than is required for sound.

For color sensitometry, several intensity-scale instruments and photoelectric densitometers with color filter attachments have been made available, including the Eastman Processing Control, Ansco, Houston and Herrnfeld sensitometers, and the Ansco, Eastman Type 31A (Fig. 46) and Westrex color densitometers.[79–85]

In printing color film, variation of the hue as well as of the intensity of the printing light is accomplished either by

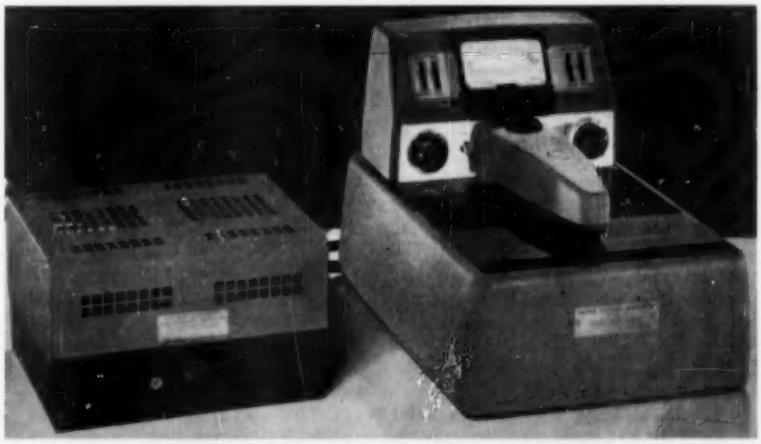


Fig. 46. The Eastman Electronic Densitometer, Model 31A (1954).

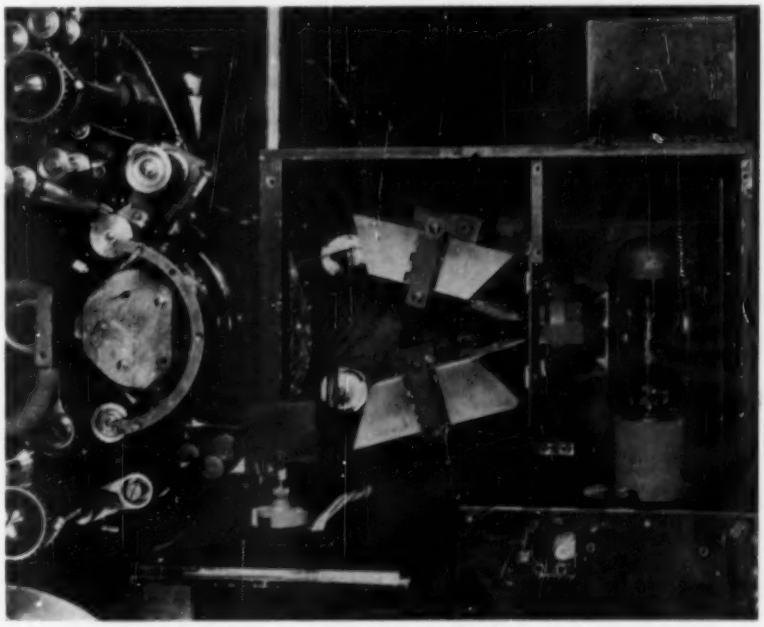


Fig. 47. The Streiffert Printer (1952).

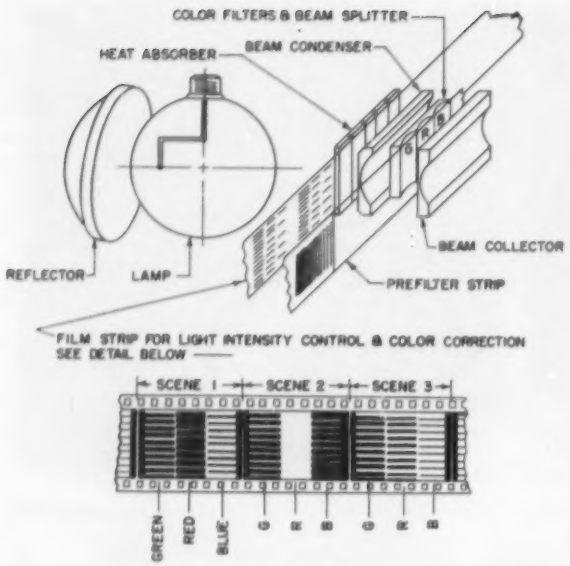


Fig. 48. Illustrating the optical principles of the Debrie Matipo Step Printer. Additive color mixture is effected by the use of a line-screen control matte in combination with prismatic lenses and three filter elements (1953).

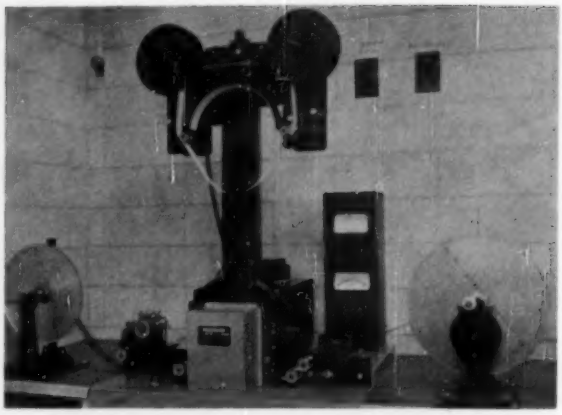


Fig. 49. The Herrnfeld Scene Tester (1951).

means of individual filters, filter packs with or without neutral density filters, or by intermixing the three primary colors projected onto the printing aperture. For each scene, the filter or pack may be changed as is done in an automatic slide projector, or, more generally, a traveling matte or "cuing strip" is employed with varying apertures in combination with filters to modulate the intensity and hue of the printing light.

Additive printing with narrow band filters gives improved color saturation. In the Streiffert printer (Fig. 47), light from a single lamp is divided into three beams which are individually filtered, controlled in intensity by rotating vanes, and projected onto the printer aperture. Control is by means of punch holes in a control filmstrip which can also be adapted for scene testing.[220] The Debrie Matipo step color printer likewise employs the additive color-mixture principle effected by the use of a line screen control matte in combination with prismatic lenses and three filter elements (Fig. 48).[50]

It is customary to check the intensity and color quality at the printer aperture with a suitable photocell using standardized filters.[218] Notching of the film for scene changes is avoided by painting the edge of the film at intervals with a conducting paint which serves to actuate a solenoid.

For scene testing, the color positive may be exposed through the negative with a range of color-correcting filters under conditions which correspond to the printer exposure times, intensity and color balance. Typical scene testers include the Reeves, Houston-Fearless and the Herrnfeld instruments. The latter employs a curved platen with sixteen filter variants and the light, modulated by varying apertures, is directed to the film by a rotating mirror which scans the curved printing platen (Fig. 49).

The Future

The work of the motion-picture laboratory is becoming more and more technical, requiring the combined efforts of mechanical engineers, chemists and physicists to produce pictures having the maximum definition and photographic quality of which the film is capable, in the shortest possible time and at the least cost.

The significant growth of 16mm film in the professional field, and especially that of television, combined with the demands of color processing, will necessitate greater refinement of laboratory mechanisms and procedures in the future but I am sure that the facilities which our Society is providing for cooperative effort will contribute greatly to attainment of these goals.

The author wishes to acknowledge the assistance of his colleagues, C. E. Ives and A. R. Turner, in the preparation of this paper.

Discussion

John G. Frayne (Westrex Corp.): I saw no reference to the Western Electric 1100A Densitometer which was introduced around 1940, I believe, and which played a great part in standardizing sensitometry and the processing of variable-density films as well as black-and-white pictures. I believe this instrument should have some reference in the paper.

Mr. Crabtree: I gave a reference to that, although I didn't show an illustration.

E. W. Kellogg (Consulting Engineer, formerly of RCA): How large a part in the overall picture of sound printing was played by the nonslip printer, first brought to public attention through the work of C. N. Batsel about 1932?

Mr. Crabtree: The nonslip principle has not played a very important part in the evolution of the laboratory and, so far as I know, is not currently employed. Although the films do not tend to slip longitudinally, they may periodically slip laterally.

Mr. Kellogg: May I add an item to what you just said? A recent letter I had from Art Blaney was to the effect that although the nonslip printers were not very widely used, and displaced other types of printer only in a few laboratories, they did, by demonstrating what they could do with variable-area tracks in the way of improving definition, force refinements and better performance of sound printers throughout the industry.

Sidney P. Solow (Consolidated Film Industries): I think your paper helps point out that rather than being an adjunct, the laboratory is really the nucleus of a motion-picture enterprise and that if a country somewhere in the world would like to establish a native motion-picture industry they had better first consider establishing a laboratory.

BIBLIOGRAPHY

AGITATION, DEVELOPER

1. J. Crabtree, "Directional effects in continuous film processing," *Jour. SMPE, 18:* 207, Feb. 1932.
2. J. Crabtree, "Uniformity in photographic development," *Jour. SMPE, 25:* 512, Dec. 1935.
3. C. E. Ives and C. J. Kunz, "Solution agitation by means of compressed air," *Jour. SMPE, 34:* 364, Apr. 1940.
4. J. I. Crabtree and C. H. Schwingel, "Effect of aeration on the photographic properties of developers," *Jour. SMPE, 34:* 375, Apr. 1940.
5. B. C. Sewell, "The directional effect in machine development," *J. Brit. Kinemat. Soc., 3:* 84, Apr. 1940.
6. M. S. Leshing, T. M. Ingman and K. Pier, "Reduction of development sprocket-hole modulation," *Jour. SMPE, 36:* 475, May 1941.
7. C. E. Ives and E. W. Jensen, "The effect of developer agitation on density uniformity and rate of development," *Jour. SMPE, 40:* 107, Feb. 1943.
8. M. S. Leshing and T. M. Ingman, "Some turbulation characteristics of the new Twentieth Century-Fox Developing Machine," *Jour. SMPE, 44:* 97, Feb. 1945.
9. G. I. P. Levenson, "Chemical economics of spray processing," *Jour. SMPE, 53:* 665, Dec. 1949.
10. C. E. Ives, "The application of treating liquids and drying air in photographic processing," *Phot. Eng., 2:* No. 3, 116, 1951.

AIR CONDITIONING

11. D. C. Lindsay, "Air conditioning as applied in theaters and film laboratories," *Trans. SMPE*, No. 11, 334, Aug. 1927.
12. A. H. Simonds and L. H. Polderman, "Air conditioning in film laboratories," *Jour. SMPE, 17:* 604, Oct. 1931.
13. E. C. Holden, "Silica gel air-conditioning for film processing," *Jour. SMPE, 18:* 471, Apr. 1932.

ANALYSES (CHEMICAL), OF PROCESSING SOLUTIONS

14. R. M. Evans and W. T. Hanson, Jr., "Chemical analysis of an MQ developer," *Jour. SMPE, 32:* 307, Mar. 1939.
15. H. L. Baumbach, "Chemical analysis of hydroquinone, metol, and bromide in a photographic developer," *Jour. SMPE, 33:* 517, Nov. 1939.
16. R. B. Atkinson and V. C. Shaner, "Chemical analysis of photographic developers and fixing baths," *Jour. SMPE, 34:* 485, May 1940.
17. R. M. Evans, W. T. Hanson, Jr. and P. K. Glasoe, "Synthetic aged developers by analysis," *Jour. SMPE, 38:* 188, Feb. 1942.
18. J. G. Stott, "Application of potentiometric methods of developer analysis," *Jour. SMPE, 39:* 37, July 1942.
19. W. R. Crowell, W. W. Luke and H. L. Baumbach, "Potentiometric determination of bromide in the presence of chloride in photographic developer solutions," *Jour. SMPE, 44:* 472, June 1945.
20. V. C. Shaner and M. R. Sparks, "Application of the Polarograph to the analysis of photographic fixing baths," *Jour. SMPE, 45:* 20, July 1945.
21. H. L. Baumbach, "An improved method for the determination of hydroquinone and metol in photographic developers," *Jour. SMPE, 47:* 403, Nov. 1946.
22. V. C. Shaner and M. R. Sparks, "Application of methyl ethyl ketone to the analysis of developers for elon and hydroquinone," *Jour. SMPE, 47:* 409, Nov. 1946.
23. G. I. P. Levenson, "Controlling the elon-hydroquinone developer," *Brit. Kinemat., 12:* No. 2, 37, Feb. 1948.
24. A. H. Brunner, P. B. Means and R. H. Zappert, "Analysis of developers and bleach for Ansco Color Film," *Jour. SMPE, 53: 25,* July 1949.
25. H. L. Rees and D. H. Anderson, "Simultaneous determination of elon and hydroquinone in photographic developers," *Jour. SMPE, 53:* 268, Sept. 1949.

APPARATUS (PROCESSING)

26. J. I. Crabtree and C. E. Ives, "Improvements in motion picture laboratory apparatus," *Trans. SMPE*, No. 18, 161, May 1924.
27. J. I. Crabtree and C. E. Ives, "A pneumatic film squeegee," *Trans. SMPE*, No. 11, 270, Aug. 1927.
28. C. E. Ives, A. J. Miller and J. I. Crabtree, "Improvements in motion picture laboratory apparatus," *Jour. SMPE, 17:* 26, July 1931.
29. J. A. Dubray, "The evolution of motion picture film processing apparatuses," *Cinemat. Ann., vol. 2:* 271, 1931.
30. C. E. Ives, "A roller developing rack for continuously moving the film during processing by the rack-and-tank system," *Jour. SMPE, 24:* 261, Mar. 1935.
31. "The Davidge Developing Apparatus," *Jour. SMPE, 24:* 452, May 1935.
32. C. E. Ives, "An improved roller type developing rack with stationary drive," *Jour. SMPE, 31:* 393, Oct. 1938.
33. R. S. Leonard, "A reel and tray developing machine," *Jour. SMPE, 34:* 168, Feb. 1940.
34. B. Robinson and M. S. Leshing, "New gadgets for the film laboratory," *Jour. SMPE, 37:* 274, Sept. 1941.
35. C. E. Ives and C. J. Kunz, "The flat spiral reel for processing 50-foot lengths of film," *Jour. SMPE, 42:* 349, June 1944.
36. G. I. P. Levenson, "New Debrie processing machine," *Funct. Phot., vol. 2:* 13, Sept. 1951.
37. F. D. Miller, "Rapid drying of normally processed black-and-white motion picture film," *Jour. SMPTE, 60:* 85, Feb. 1953.

CLEANING

38. T. Faulkner, "Cleaning motion picture positive film," *Trans. SMPE*, No. 25, 117, Sept. 1926.
39. J. I. Crabtree and H. C. Carlton, "Cleaning liquids for motion picture film," *Trans. SMPE*, No. 11, 277, Aug. 1927.
40. A. S. Dworsky, "The Dworsky film-renovating machine, polishing machine, and film rewind," *Trans. SMPE*, No. 11, 774, Sept. 1927.

COLOR FILM, PROCESSING

41. W. V. D. Kelley, "The Handschiegl and Pathéchrome Color Processes," *Jour. SMPE, 17:* 230, Aug. 1931.
42. E. R. Davies, "The Kodachrome process of 16-mm colour kinematography," *Phot. J.* (Roy. Phot. Soc.), *76:* 248, Apr. 1936.
43. J. L. Forrest, "Machine processing of 16-mm Ansco Color Film," *Jour. SMPE, 45:* 313, Nov. 1945.
44. J. E. Bates and I. V. Runyan, "Processing color procedures for Ansco Color Film," *Jour. SMPE, 53:* 3, July 1949.
45. A. B. Jennings, W. A. Stanton and J. P. Weiss, "Synthetic color-forming binders for photographic emulsions," *Jour. SMPTE, 55:* 455, Nov. 1950.
46. W. Hedden, T. Weaver and L. Thompson, "Processing of 16-mm Kodachrome Prints," *Jour. SMPTE, 57:* 308, Oct. 1951.
47. W. T. Hanson, Jr., "Color negative and color positive film for motion picture use," *Jour. SMPTE, 58:* 223, Mar. 1952.
48. H. H. Duerr, "The Ansco color negative-positive process," *Jour. SMPTE, 58:* 465, June 1952.
49. C. R. Anderson, N. H. Groet, C. A. Horton and D. M. Zwick, "An intermediate positive-internegative system for color motion-picture photography," *Jour. SMPTE, 60:* 217, Mar. 1953.
50. R. H. Cricks, "New processing equipment for colour film," *Funct. Phot., 5:* 10, Oct. 1953.

CONSTRUCTION MATERIALS

51. J. I. Crabtree, G. E. Matthews and J. F. Ross, "Materials for the construction of motion picture processing apparatus," *Jour. SMPE, 26:* 330, Mar. 1931.
52. W. M. Mitchell, "Applications of stainless steels in the motion picture industry," *Jour. SMPE, 24:* 346, Apr. 1935.
53. R. L. Foote, "Laminated Bakelite in the motion picture industry," *Jour. SMPE, 24:* 354, Apr. 1935.
54. F. L. LaQue, "Inconel as a material for photographic film processing apparatus," *Jour. SMPE, 24:* 357, Apr. 1935.
55. F. L. LaQue, "Some general characteristics of chromium-nickel-iron alloys as corrosion-resisting materials," *Jour. SMPE, 32:* 505, May 1939.
56. B. H. Thompson, "Present and proposed uses of plastics in the motion picture industry," *Jour. SMPE, 43:* 106, Aug. 1944.
57. L. E. Muehler and J. I. Crabtree, "The relative corrosion effect on stainless steels of rapid fixing baths containing ammonium chloride and ammonium sulfate," *PSA Jour., 13:* 30, Jan. 1947.
58. A. B. Everest and F. Hudson, "Metals in kinema and related equipment," *Brit. Kinemat., 12:* 109, Apr. 1948.
59. L. E. Muehler and J. I. Crabtree, "Materials of construction for photographic processing equipment," *PSA Jour.* (*Phot. Sci. & Tech.*), *vol. 19B:* No. 2, 79, May 1953; *ibid., vol. 19B:* No. 3, 92, Aug. 1953.

DEFECTS

60. J. I. Crabtree and G. E. Matthews, "A study of the markings on motion picture film produced by drops of water, condensed water vapor and abnormal drying conditions," *Trans. SMPE*, No. 17, 29, Oct. 1923.
61. J. I. Crabtree and C. E. Ives, "Rack marks and airbell markings on motion picture film," *Trans. SMPE, No. 24,* 95, Oct. 1925.
62. J. I. Crabtree and G. E. Matthews, "Oil spots on motion picture film," *Trans. SMPE*, No. 11, 728, Sept. 1927.
63. J. I. Crabtree and G. E. Matthews, "Effect of the water supply in processing motion picture film," *Jour. SMPE, 16:* 437, Apr. 1931.
64. R. W. Henn and J. I. Crabtree, "Calcium scums and sludges in photography," *Jour. SMPE, 43:* 426, Dec. 1944.

DENSITOMETERS

65. J. G. Capstaff and N. B. Green, "A motion picture densitometer," *Trans. SMPE*, No. 17, 154, Oct. 1923.
66. J. G. Capstaff and R. A. Purdy, "A compact motion picture densitometer," *Trans. SMPE*, No. 11, 607, Sept. 1927.
67. F. L. Eich, "A physical densitometer for sound processing laboratories," *Jour. SMPE, 24:* 180, Feb. 1935.
68. C. M. Tuttle, "A recording physical densitometer," *J. Opt. Soc. Am., 26:* 282, July 1936.
69. C. M. Tuttle and M. E. Russell, "Note on the use of an automatic recording densitometer," *Jour. SMPE, 28:* 99, Jan. 1937.
70. W. W. Lindsay and W. V. Wolfe, "A wide range, linear-scale photoelectric cell densitometer," *Jour. SMPE, 28:* 622, June 1937.
71. R. M. Evans, "Color densitometer for subtractive processes," *Jour. SMPE, 31:* 194, Aug. 1938.

72. D. R. White, "A direct reading photoelectric densitometer," *Jour. SMPE, 33:* 403, Oct. 1939.
73. J. G. Frayne and G. R. Crane, "A precision integrating sphere densitometer," *Jour. SMPE, 35:* 184, Aug. 1940.
74. J. G. Frayne, "Measurement of photographic printing density," *Jour. SMPE, 36:* 622, June 1941.
75. M. H. Sweet, "Precision direct-reading densitometer," *Jour. SMPE, 38:* 148, Feb. 1942.
76. J. G. Frayne and G. R. Crane, "Automatic recording of photographic densities," *Jour. SMPE, 45:* 370, Nov. 1945.
77. A. F. Thiels, "A direct-reading equivalent densitometer," *Jour. SMPTE, 56:* 13, Jan. 1951.
78. G. Barnes, "An automatic recording photographic densitometer," *J. Opt. Soc. Am., 43:* 1176, Dec. 1953.

DENSITOMETERS (COLOR)

79. R. M. Evans, "A color densitometer for subtractive processes," *Jour. SMPE, 31:* 194, Aug. 1938.
80. M. H. Sweet, "The densitometry of modern reversible color film," *Jour. SMPE, 44:* 419, June 1945.
81. M. H. Sweet, "An improved photomultiplier tube color densitometer," *Jour. SMPTE, 54:* 35, Jan. 1950.
82. A. C. Lapsley and J. P. Weiss, "A versatile densitometer for color films," *Jour. SMPTE, 56:* 23, Jan. 1951.
83. "Color densitometer," Photo Research Corp., *Jour. SMPTE, 57:* 400, Oct. 1951.
84. F. P. Herrnfeld, "Integrating-type color densitometer," *Jour. SMPTE, 59:* 184, Sept. 1952.
85. K. G. Macleish, "Transmission densitometers for color films," *Jour. SMPTE, 60:* 696, June 1953.

DEVELOPERS AND REPLENISHMENT

86. J. I. Crabtree and M. L. Dundon, "Investigations on photographic developers. Sulfide fog by bacteria in motion picture developers," *Trans. SMPE,* No. 19, 28, Sept. 1924.
87. J. I. Crabtree, "The handling of motion picture film at high temperatures," *Trans. SMPE,* No. 19, 39, Sept. 1924.
88. J. I. Crabtree and M. L. Dundon, "The staining properties of motion picture developers," *Trans. SMPE,* No. 25, 108, Sept. 1926.
89. J. I. Crabtree and M. L. Dundon, "Investigations on photographic developers. The effect of desensitizers in development," *Trans. SMPE,* No. 26, 111, Nov. 1926.
90. M. L. Dundon and J. I. Crabtree, "The fogging properties of developers," *Trans. SMPE,* No. 36, 1096, Sept. 1928.
91. H. C. Carlton and J. I. Crabtree, "Some properties of fine grain developers for motion picture film," *Trans. SMPE,* No. 13, 406, May 1929.
92. H. W. Moyse and D. R. White, "Borax developer characteristics," *Trans. SMPE,* No. 13, 445, May 1929.
93. J. I. Crabtree and C. E. Ives, "A replenishing solution for a motion picture positive film developer," *Jour. SMPE, 15:* 627, Nov. 1930.
94. R. M. Evans, "Maintenance of a developer by continuous replenishment," *Jour. SMPE, 31:* 273, Sept. 1938.
95. J. I. Crabtree and R. W. Henn, "An improved fine grain developer formula," *PSA Jour., 4:* 1, 1938.
96. J. I. Crabtree and G. E. Matthews, *Photographic Chemicals and Solutions,* American Photographic Publishing Co., Boston, Mass., 1939.
97. H. L. Baumbach, "Continuous replenishment and chemical control of motion picture developing solutions," *Jour. SMPE, 39:* 55, July 1942.
98. H. A. Miller, R. W. Henn, and J. I. Crabtree, "Methods of increasing film speed," *PSA Jour. 12:* 586, Nov. 1946.
99. A. A. Rasch and J. I. Crabtree, "Development of motion-picture positive film by vanadous ion," *Jour. SMPTE, 62:* 1, Jan. 1954.

DUPLICATION

100. Booklet: *Eastman Duplicating Film—Its Properties and Uses,* Eastman Kodak Co., Rochester, N.Y., Jan. 1927.
101. J. G. Capstaff and M. W. Seymour, "The duplication of motion picture negatives," *Trans. SMPE,* No. 28, 223, Feb. 1927.
102. C. E. Ives and E. Huse, "Notes on making duplicate negatives," *Trans. SMPE,* No. 34, 382, Apr. 1928.
103. O. B. Depue, "Machinery for making duplicate negatives," *Trans. SMPE,* No. 12, 1170, Sept. 1928.
104. J. I. Crabtree and C. H. Schwingel, "The duplication of motion picture negatives," *Jour. SMPE, 19:* 891, July 1932.
105. C. E. Ives and J. I. Crabtree, "Two new films for duplicating work," *Jour. SMPE, 29:* 317, Sept. 1937.
106. W. H. Offenhauser, Jr., "Some notes on the duplication of 16-mm integral tripack color films," *Jour. SMPE, 45:* 113, Aug. 1945.
107. N. L. Simmons and E. Huse, "Current black-and-white duplicating techniques used in Hollywood," *Jour. SMPE, 49:* 316, Oct. 1947.

EDITING

108. G. E. Hoglund, "Apparatus for preparing moving picture films," U.S. Pat. 971,889, Oct. 4, 1910.
109. F. D. Williams, "Methods of blooping," *Jour. SMPE, 30:* 105, Jan. 1938.
110. W. H. Offenhauser, Jr., "Current practices in blooping sound-film," *Jour. SMPE, 35:* 165, Aug. 1940.
111. I. J. Wilkinson and W. H. Hamilton "Motion picture editing," *Jour. SMPE, 36:* 101, Jan. 1941.
112. L. A. Elmer, "A non-cinching film rewind machine," *Jour. SMPE, 37:* 418, Oct. 1941.
113. H. A. Witt, "Practical aspect of edge-numbering 16-mm film," *Jour. SMPE, 39:* 67, July 1942.
114. F. Y. Smith, "Cutting and editing of motion pictures," *Jour. SMPE, 39:* 284, Nov. 1942.
115. L. Sherwood, "Editing and photographic embellishments as applied to 16-mm industrial and educational motion pictures," *Jour. SMPE, 41:* 476, Dec. 1943.
116. L. Thompson, "16-mm edge-numbering machine," *Jour. SMPE, 45:* 109, Aug. 1945.

FIXING

117. J. I. Crabtree and H. A. Hartt, "Some properties of fixing baths," *Trans. SMPE,* No. 38, 364, May, 1929.
118. J. I. Crabtree and H. D. Russell, "Some properties of chrome alum stop baths and fixing baths—Part I," *Jour. SMPE, 14:* 483, May 1930; Part II, *ibid., 14:* 667, June 1930.
119. J. I. Crabtree, L. E. Muehler and H. D. Russell, "New stop bath and fixing bath formulas and methods for their revival," *Jour. SMPE, 38:* 353, Apr. 1942.
120. D. B. Alnutt, "Some characteristics of ammonium thiosulfate fixing baths," *Jour. SMPE, 41:* 300, Oct. 1943.

HISTORY, EARLY

121. C. E. K. Mees, "A new substandard film for amateur cinematography," *Trans. SMPE,* No. 16, 252, May 1923.
122. G. Coissac, *Histoire du cinématographe,* Gauthier Villars, Paris, 1925, p. 309.
123. C. L. Gregory, "Early history of motion picture cameras for film wider than 35-mm," *Jour. SMPE, 14:* 27, Jan. 1930.
124. E. K. Scott, "Career of L. A. A. LePrince," *Jour. SMPE, 17:* 46, July 1931.
125. A. C. Bromhead, "Reminiscences of the British film trade," *Proc. Brit. Kinemat. Soc., 21:* 12, 1933.
126. E. R. Theisen, "The history of nitrocellulose as a film base," *Jour. SMPE, 20:* 259, Mar. 1933.
127. W. K. L. Dickson, "A brief history of the Kinetograph, the Kinetoscope and the Kineto-Phonograph," *Jour. SMPE, 21:* 435, Dec. 1933.
128. R. W. Paul, C. M. Hepworth and W. Barker, "Before 1910 kinematograph experiences," *Proc. Brit. Kinemat. Soc.,* No. 38, 9, 1936.
129. O. Meester, *Mein weg mit dem film,* Schoneberg, Paris, 1936.
130. R. W. Paul, "Kinematographic experiences," *Jour. SMPE, 27:* 495, Nov. 1936.
131. L. Lumière, "The Lumière cinematograph," *Jour. SMPE, 27:* 640, Dec. 1936.
132. W. E. Theisen, "Pioneering in the talking picture," *Jour. SMPE, 36:* 415, Apr. 1941.
133. Jean Vivié, *Traité général de technique du cinéma. Vol. I—Historique et développement de la technique cinématographique,* Editions B. P. I., Paris, 1946.
134. R. H. Cricks, "British influence in the technical development of kinematography, *Brit. Kinemat., 11:* 1, July, 1947.
135. G. Sadoul, *Les pionniers du cinéma,* Editions Denoel, Paris, 1949, p. 282.
136. A. Cornwell-Clyne, *Colour cinematography,* Chapman & Hall, London, 3rd edition, 1951.
137. J. I. Crabtree, "The development of motion picture film by the reel and tank systems," *Trans. SMPE,* No. 16, 163, May 1923.
138. L. M. Griffith, "The technical status of the film laboratory," *Trans. SMPE,* No. 33: 173, Apr. 1928.
139. T. E. Shea, "A modern laboratory for the study of sound picture problems," *Jour. SMPE, 16:* 277, Mar. 1931.
140. B. Burns, "The multicolor laboratory," *Jour. SMPE, 17:* 11, July 1931.
141. I. D. Wratten, "Motion picture film processing in Great Britain," *Jour. SMPE, 26:* 204, Feb. 1936.
142. Report of Committee on Laboratory Practice, D. E. Hyndman, Chairman, *Jour. SMPE, 26:* 345, Apr. 1936.
143. C. L. Lootens, "A modern motion picture laboratory," *Jour. SMPE, 30:* 363, Apr. 1938.
144. G. M. Best and F. R. Gage, "A modern studio laboratory," *Jour. SMPE, 35:* 294, Sept. 1940.
145. J. R. Wilkinson, "Motion picture laboratory practices," *Jour. SMPE, 39:* 166, Sept. 1942.
146. L. Thompson, "Practical side of direct 16-mm laboratory work," *Jour. SMPE, 41:* 101, July 1943.
147. W. H. Offenhauser, Jr., "A 16-mm commercial film laboratory," *Jour. SMPE, 41:* 157, Aug. 1943.
148. W. H. Offenhauser, Jr., *16-mm Sound Motion Pictures,* Interscience Publishers, New York, N.Y., 1949.
149. H. C. Harsh and K. Schadlich, "Laboratory for development work on color motion pictures," *Jour. SMPE, 53:* 50, July 1949.
149a. C. E. K. Mees, "History of professional black-and-white motion-picture film, *Jour. SMPTE, 63:* 134, Oct. 1954.

MACHINES, PROCESSING

150. R. C. Hubbard, "Erbograph machine. A friction feed developing machine for developing positive motion picture film," *Trans. SMPE,* No. 17, 163, Oct. 1923.
151. R. C. Hubbard, "The straight line developing machine," *Trans. SMPE,* No. 18, 73, May 1924.
152. A. B. Hitchins, "Machine development of negative and positive motion picture film," *Trans. SMPE,* No. 22, 46, May 1925.
153. C. R. Hunter, "Developer perfected," *Am. Cinemat., 8:* 17, Feb. 1928.

154. C. R. Hunter, "A negative developing machine," *Trans. SMPE*, No. 33, 195, Apr. 1928.
155. H. J. Jamieson, "A horizontal tray type of continuous processing machine," *Trans. SMPE*, No. 36, 1093, Sept. 1928.
156. C. R. Hunter and R. M. Pierce, "A method for quantity developing of motion picture films," *Jour. SMPE, 17:* 954, Dec. 1931.
157. H. D. Hineline, "Continuous photographic processing," *Jour. SMPE, 26:* 38, Jan. 1936.
158. W. Stull, "The Paramount transparency air-turbine developing machine," *Am. Cinemat., 17:* 236, June 1936.
159. A. Reeves, "Laboratory equipment for the smaller laboratory," *Jour. SMPE, 29:* 446, Oct. 1937.
160. J. M. Blaney, "A new 16-mm film developing machine," *Jour. SMPE, 32:* 495, May 1939.
161. J. F. VanLeuven, "Simplifying and controlling film travel through a developing machine," *Jour. SMPE, 33:* 583, Nov. 1939.
162. W. G. C. Bosco, "An all-friction drive for developing machines," *Am. Cinemat., 26:* 122, Apr. 1945.
163. R. P. Ireland, "A motion picture film developing machine," *Jour. SMPE, 50:* 50, Jan. 1948.
164. G. I. P. Levenson, "An experimental processing machine," *Kinemat. Weekly, 392:* No. 2217, 41, Oct. 27, 1949.
165. A. M. Gundelfinger, "Cinecolor three-color process," *Jour. SMPTE, 54:* 74, Jan. 1950.
166. R. H. Bomback, "Agfacolor process," *Funct. Phot., 1:* No. 4, 15, Jan. 1950.
167. J. S. Hall, A. Mayer and G. Maslach, "A 16-mm rapid film processor," *Jour. SMPTE, 55:* 27, July 1950.
168. H. E. Hewston and C. H. Elmer, "Continuous processing machine for wide film," *Jour. SMPTE, 56:* 613, June 1951.
169. A. L. Holcomb, "Film-spool drive with torque motors," *Jour. SMPTE, 58:* 28, Jan. 1952.
170. J. W. Kaylor and A. V. Pesek, "Cinecolor multilayer color developing machine," *Jour. SMPTE, 58:* 53, Jan. 1952.
171. J. A. Tanney and E. B. Krause, "The Bridgamatic developing machine," *Jour. SMPTE, 60:* 260, Mar. 1953.

MAGNETIC STRIPING

172. S. J. Begun, "Recent developments in the field of magnetic recording," *Jour. SMPE, 48:* 1, Jan. 1947.
173. M. Camras, "Magnetic sound for motion pictures," *Jour. SMPE, 48:* 14, Jan. 1947.
174. M. Camras, "Recent developments in magnetic recording for motion picture film," *J. Acoust. Soc. Am., 19:* 322, Mar. 1947.
175. E. Schmidt and E. W. Franck, "Manufacture of magnetic recording materials," *Jour. SMPTE, 60:* 453, Apr. 1953.
176. E. Schmidt, "Commercial experiences with Magnastripe," *Jour. SMPTE, 60:* 463, Apr. 1953.
177. B. L. Kaspin, A. Roberts, Jr., H. Robbins and R. L. Powers, "Magnetic striping techniques and characteristics," *Jour. SMPTE, 60:* 470, Apr. 1953.
178. T. R. Dedell, "Magnetic sound tracks for processed 16-mm motion picture film," *Jour. SMPTE, 60:* 491, Apr. 1953.

PRESERVATION AND STORAGE

179. J. I. Crabtree and J. F. Ross, "A method of testing for the presence of sodium thiosulfate in motion picture film," *Jour. SMPE, 14:* 419, Apr. 1930.
180. J. I. Crabtree and C. E. Ives, "The storage of valuable motion picture film," *Jour. SMPE, 15:* 298, Sept. 1930.
181. J. A. Norling and A. P. Rippenbein, "Treatment for rejuvenating and preserving motion picture film," *Jour. SMPE, 16:* 766, June 1931.
182. E. W. Fowler and L. B. Newell, "Storage and handling of motion picture film," *Jour. SMPE, 16:* 773, June 1931.
183. J. R. Hill and C. G. Weber, "Stability of motion picture films as determined by accelerated aging," *Jour. SMPE, 27:* 677, Dec. 1936.
184. J. G. Bradley, "Changing aspects of the film-storage problem," *Jour. SMPE, 30:* 303, Mar. 1938.
185. J. E. Gibson and C. G. Weber, "Evaluation of motion picture films by semimicro testing," *Jour. SMPE, 32:* 105, Jan. 1939.
186. Report of the Committee on Preservation of Film, *Jour. SMPE, 35:* 584, Dec. 1940.
187. R. H. Talbot, "New treatment for the prevention of film abrasion and oil mottle," *Jour. SMPE, 36:* 191, Feb. 1941.
188. J. I. Crabtree, G. T. Eaton and L. E. Muehler, "A review of hypo testing methods," *Jour. SMPE, 42:* 34, Jan. 1944.
189. W. H. Offenhauser, Jr., "A plan for preserving 16-mm originals of educational films," *Jour. SMPE, 43:* 418, Dec. 1944.
190. G. L. Sarchet, "Preservation and postwar utilization of U.S. Navy combat film," *Jour. SMPE, 48:* 476, May 1947.
191. J. G. Bradley, "Film vaults: construction and use," *Jour. SMPE, 53:* 193, Aug. 1949.
192. H. G. Brown, "Problems of storing film for archive purposes," *Brit. Kinemat., 20:* 150, May 1952.
193. American Standard Method for Determining the Thiosulfate Content of Processed Photographic Film, PH4.8-1953, ASA, New York, N.Y.

PRINTERS

194. O. B. Depue, "A daylight optical reduction printer," *Trans. SMPE*, No. 28, 242, Feb. 1927.
195. A. B. Hitchins, "Duplex optical printers," *Trans. SMPE*, No. 32, 771, Sept. 1927.
196. C. L. Gregory, "An optical printer for trick work," *Trans. SMPE*, No. 34, 419, Apr. 1928.
197. O. B. Depue, "Machinery for making duplicate negatives," *Trans. SMPE*, No. 36, 1170, Sept. 1928.
198. O. B. Depue, "A printer for simultaneous printing of sound and picture negatives," *Trans. SMPE*, No. 37, 150, May 1929.
199. O. B. Depue, "A machine for printing picture and sound simultaneously and automatically," *Jour. SMPE, 18:* 643, May 1932.
200. R. V. Wood, "A shrinkage-compensating sound printer," *Jour. SMPE, 18:* 788, June 1932.
201. A. S. Howell, B. E. Stechbart and R. F. Mitchell, "The Bell & Howell fully automatic sound picture production printer," *Jour. SMPE, 19:* 305, Oct. 1932.
202. A. S. Howell and R. F. Mitchell, "Recent improvements in the Bell & Howell fully automatic printer," *Jour. SMPE, 22:* 115, Feb. 1934.
203. A. F. Victor, "Continuous optical reduction printing," *Jour. SMPE, 23:* 96, Aug. 1934.
204. C. N. Batsel, "A non-slip sound printer," *Jour. SMPE, 23:* 100, Aug. 1934.
205. O. Sandvik and J. G. Streiffert, "A continuous optical reduction sound printer," *Jour. SMPE, 25:* 117, Aug. 1935.
206. D. H. Geary, "The Vinten Dufaycolor printer," *J. Brit. Kinemat. Soc., 2:* No. 3, 185, July 1939.
207. The Bell & Howell 35-mm non-slip sound printer," *Jour. SMPE, 33:* 125, Aug. 1939.
208. L. S. Dunn, "The new Acme-Dunn optical printer," *Jour. SMPE, 42:* 204, Apr. 1944.
209. C. W. Clutz, F. E. Altman and J. G. Streiffert, "35-mm to 16-mm sound reduction printer," *Jour. SMPE, 52:* 669, June 1949.
210. F. P. Herrnfeld, "Printing equipment for Ansco color film," *Jour. SMPTE, 54:* 454, Apr. 1950.

PRINTING METHODS

211. W. E. Story, Jr., "Actinic measurements in the exposing and printing of motion picture film," *Trans. SMPE*, No. 13, 106, Oct. 1921.
212. R. C. Hubbard, "Printing motion picture film," *Trans. SMPE*, No. 28, 252, Feb. 1927.
213. J. Crabtree, "Sound film printing," *Jour. SMPE, 21:* 294, Oct. 1933; *ibid., 22:* 98, Feb. 1934.
214. G. L. Dimmick, C. N. Batsel and L. T. Sachtleben, "Optical reduction sound printing," *Jour. SMPE, 23:* 108, Aug. 1934.
215. G. L. Dimmick, "Improved resolution in sound recording and printing by the use of ultraviolet light," *Jour. SMPE, 27:* 168, Aug. 1936.
216. P. S. Aex, "A photoelectric method for determining color balance of 16-mm Kodachrome duplicating printers," *Jour. SMPE, 49:* 425, Nov. 1947.
217. F. LaGrande, C. R. Daily and B. H. Denney, "16-mm release printing using 35- and 32-mm film," *Jour. SMPE, 52:* 211, Feb. 1949.
218. C. A. Horton, "Printer control in color printing," *Jour. SMPTE, 58:* 239, Mar. 1952.
219. R. L. Sutton, K. B. Curtis and L. Thompson, "Prints from 16mm originals," *Jour. SMPTE, 58:* 145, Feb. 1952.
220. J. G. Streiffert, "A fast-acting exposure control system for color motion picture printing," *Jour. SMPTE, 59:* 410, Nov. 1952.

PROCESSING

221. J. Lachenbruch, "German efficiency in their laboratories," *M. P. News, 26:* No. 24, 2958, Dec. 9, 1922.
222. Report of Committee on Film and Emulsions, *Trans. SMPE*, No. 16, 274, May 1923.
223. L. A. Jones and J. I. Crabtree, "Panchromatic negative film for motion pictures," *Trans. SMPE*, No. 27, 131, Jan. 1927.
224. V. A. Stewart, "Improvements in laboratory practice," *Trans. SMPE*, No. 32, 651, Sept. 1927.
225. R. F. Nicholson, "The processing of variable-density sound records," *Jour. SMPE 15:* 374, Sept. 1930.
226. J. Crabtree, "Directional effects in continuous film processing," *Jour. SMPE, 18:* 207, Feb. 1932.
227. Report of the Progress Committee, *Jour. SMPE, 19:* 134, Aug. 1932.
228. J. Crabtree and J. H. Waddell, "Directional effects in sound-film processing, Part II," *Jour. SMPE, 21:* 351, Nov. 1933.
229. J. Crabtree, "Uniformity in photographic development," *Jour. SMPE, 25:* 512, Dec. 1935.
230. *Motion Picture Laboratory Practice*, Eastman Kodak Co., Rochester, N.Y., 1936.
231. I. D. Wratten, "Motion picture film laboratory practice," *Proc. Brit. Kinemat. Soc.*, No. 41, 1936.
232. L. J. Wheeler, *Principles of Cinematography*, Fountain Press, London, 1953.

PROCESSING CONTROL

233. E. Huse, "Sensitometric control in the processing of motion picture film in Hollywood," *Jour. SMPE, 21:* 54, July 1933.
234. G. A. Chambers and I. D. Wratten, "The Eastman Type IIb Sensitometer as a control instrument in the processing of motion picture film," *Jour. SMPE, 21:* 218, Sept. 1933.
235. H. L. Baumbach, "Continuous replenishment and chemical control of motion picture developing solutions," *Jour. SMPE, 39:* 55, July 1942.
236. R. H. Bomback, "The chemical control of processing solutions," *Brit. Kinemat., 20:* 119, Apr. 1952.
237. R. H. Bomback, "Technical control in the film processing laboratory," *Brit. Kinemat., 20:* 142, May 1952.

RAPID PROCESSING

238. H. Parker, Jr. and J. I. Crabtree, "Rapid processing methods," *Jour. SMPE, 26:* 406, Apr. 1936.
239. F. E. Tuttle and C. H. Green, "Photographic race-timing equipment," *Jour. SMPE, 27:* 529, Nov. 1936.
240. H. A. Miller, J. I. Crabtree and H. D. Russell, "A prehardening bath for high-temperature processing," *PSA Jour. 10:* 397 and 453, Sept. and Oct. 1944.
241. J. I. Crabtree and H. D. Russell, "Rapid processing of photographic materials," *PSA Jour., 10:* No. 9, 541, Nov. 1944.
242. R. Hodgson, "Theatre television system," *Jour. SMPE, 52:* 540, May 1949.
243. C. E. Ives and C. J. Kunz, "Simplification of motion picture processing methods," *Jour. SMPTE, 55:* 3, July 1950.
244. J. S. Hall, A. Mayer and G. Maslach, "A 16-mm rapid film processor," *Jour. SMPTE, 55:* 27, July 1950.
245. R. L. Garman and B. Foulds, "Some commercial aspects of a new 16-mm intermediate film television system," *Jour. SMPTE, 56:* 219, Feb. 1951.
246. R. Hodgson and J. Hammer, "High-temperature film processing—its effect on quality," *Jour. SMPTE, 56:* 261, Mar. 1951.
247. L. Katz, "Ultrarapid drying of motion picture film by means of turbulent air," *Jour. SMPTE, 56:* 264, Mar. 1951.

REVERSAL PROCESSING

248. H. V. Verkinderen, "Reversal processing," *Brit. Kinemat., 13:* 37, Aug. 1948.
249. H. A. Miller, H. D. Russell and J. I. Crabtree, "Direct-positive processing of the new Kodak blue base reversal films," *PSA Jour., 15:* 382, June 1949.

SCENE TESTING

250. L. A. Jones and J. I. Crabtree, "A new sensitometer for the determination of exposure in positive printing," *Trans. SMPE,* No. 15, 89, Oct. 1922.
251. C. E. Ives and J. I. Crabtree, "A trial and error method of preparing a motion picture sensitometer tablet," *Trans. SMPE,* No. 32, 740, Sept. 1927.
252. J. I. Crabtree, C. E. Ives and F. E. Tuttle, "A semi-automatic timing device for motion picture negatives," *Jour. SMPE, 15:* 587, Nov. 1930.

SENSITOMETRY

253. L. A. Jones, "A motion picture laboratory sensitometer," *Jour. SMPE, 17:* 536, Oct. 1931.
254. L. A. Jones, "Photographic sensitometry, Part I," *Jour. SMPE, 17:* 491, Oct. 1931; Part II—*ibid., 17:* 695, Nov. 1931; Part III—*ibid., 18:* 54, Jan. 1932; Part IV—*ibid., 18:* 324, Mar. 1932.
255. A. Kuster and R. Schmidt, "The sensitometric control of sound records on film," *Jour. SMPE, 19:* 539, Dec. 1932.
256. H. Meyer, "Sensitometric studies of processing conditions for motion picture films," *Jour. SMPE, 25:* 239, Sept. 1935.
257. D. R. White, "Equipment for developing and reading sensitometric tests," *Jour. SMPE, 26:* 427, Apr. 1936.
258. M. H. Sweet, "A precision direct-reading densitometer," *Jour. SMPE, 38:* 148, Feb. 1942.
259. G. A. Johnson, "A processing control sensitometer," *Jour. SMPE, 47:* 474, Dec. 1946.
260. "Principles of Color Sensitometry, Report of the Color Sensitometry Subcommittee," *Jour. SMPTE, 54:* 653, June 1950.

SILVER RECOVERY

261. J. I. Crabtree and J. F. Ross, "Silver recovery from exhausted fixing baths," *Trans. SMPE,* No. 26, 70, Nov. 1926.
262. K. Hickman, C. Sanford and W. Weyerts, "The electrolytic regeneration of fixing baths," *Jour. SMPE, 17:* 568, Oct. 1931.
263. K. Hickman, W. Weyerts and O. E. Goehler, "Electrolysis of silver-bearing thiosulfate solutions," *Ind. Eng. Chem., 25:* 202, Feb. 1933.

SOUND RECORDS, PROCESSING

264. J. B. Engl, "A new process for developing and printing photographic sound records," *Trans. SMPE,* No. 30, 257, Aug. 1927.
265. O. Sandvik and G. Silberstein, "The dependence of the resolving power of a photographic material on the wavelength of light," *J. Opt. Soc. Am., 17:* 107, Aug. 1928.
266. D. MacKenzie, "Sound recording with the light valve," *Trans. SMPE,* No. 35, 730, Sept. 1928.
267. J. W. Coffman, "Sound film processing," *Trans. SMPE,* No. 35, 799, Sept. 1928.
268. J. A. Maurer, "The photographic treatment of variable-area sound-films," *Jour. SMPE, 14:* 636, June 1930.
269. R. F. Nicholson, "The processing of variable-density sound records," *Jour. SMPE, 15:* 374, Sept. 1930.
270. D. MacKenzie, "Straight-line and toe records with the light valve," *Jour. SMPE, 17:* 172, Aug. 1931.
271. G. L. Dimmick, "Improved resolution in sound recording and printing by the use of ultraviolet light," *Jour. SMPE, 27:* 168, Aug. 1936.
272. J. O. Baker and D. H. Robinson, "Modulated high-frequency recording as a means of determining conditions for optimal processing," *Jour. SMPE, 30:* 3, Jan. 1938.
273. J. G. Frayne and R. R. Scoville, "Analysis and measurement of distortion in variable-density recording," *Jour. SMPE, 32:* 648, June 1939.
274. R. V. McKie, "Commercial processing of 16-mm variable area," *Jour. SMPE, 43:* 414, Dec. 1944.
275. R. M. Corbin, N. L. Simmons and D. E. Hyndman, "Two new Eastman fine-grain sound recording films," *Jour. SMPE, 45:* 265, Oct. 1945.
276. H. W. Moyse, "Du Pont fine-grain sound films—Types 232 and 236," *Jour. SMPE, 45:* 285, Oct. 1945.
277. W. C. Miller, "Magnetic recording for motion picture studios," *Jour. SMPE, 48:* 57, Jan. 1947.

SPLICING

278. J. I. Crabtree and C. E. Ives, "A new method of blocking out splices in sound film," *Jour. SMPE, 14:* 349, Mar. 1930.
279. J. G. Capstaff and J. S. Beggs, "Film splicer for developing machines," *Jour. SMPE, 34:* 339, Mar. 1940.
280. A. Wallingsford, "A film-splicing and repair machine," *Jour. SMPE, 47:* 254, Sept. 1946.
281. E. Baumert and J. V. Noble, "The development of an invisible 16-mm film splice," *Jour. SMPE, 48:* 231, Mar. 1947.
282. I. I. Merkur, "A new motion picture film splicer," *Jour. SMPE, 48:* 238, Mar. 1947.
283. M. S. Leshing, "An improved film splicer," *Jour. SMPE, 50:* 68, Jan. 1948.

SURFACE TREATMENT OF FILM

284. J. G. Jones, "A film waxing machine," *Trans. SMPE,* No. 15, 35, Oct. 1922.
285. J. I. Crabtree and C. E. Ives, "The lubrication of motion picture film," *Trans. SMPE,* No. 31, 522, Sept. 1927.
286. A. S. Dworsky, "The Dworsky film-renovating machine, polishing machine, and film rewind," *Trans. SMPE,* No. 32, 774, Sept. 1927.
287. J. I. Crabtree, O. Sandvik and C. E. Ives, "The surface treatment of sound film," *Jour. SMPE, 14:* 275, Mar. 1930.
288. J. I. Crabtree and C. E. Ives, "A modified film-waxing machine," *Jour. SMPE, 15:* 370, Sept. 1930.
289. J. A. Norling and A. P. Rippenbein, "Treatment for rejuvenating and preserving motion picture film," *Jour. SMPE, 16:* 766, June 1931.
290. R. H. Talbot, "A new treatment for the prevention of film abrasion and oil mottle," *Jour. SMPE, 36:* 191, Feb. 1941.
291. R. H. Talbot, "Lubrication of 16-mm films," *Jour. SMPE, 53:* 285, Sept. 1949.

WASHING

292. G. T. Eaton and J. I. Crabtree, "Washing photographic films and prints in sea water," *Jour. SMPE, 40:* 380, June 1943.
293. J. I. Crabtree, G. T. Eaton and L. E. Muehler, "The removal of hypo and silver salts from photographic materials as affected by the composition of the processing solutions," *Jour. SMPE, 41:* 9, July 1943.

Simple Electronic Timing Device for High-Speed Cinematography

By WEBSTER BLAKE

A single-pulse, simple timing system, to be used in motion-picture cameras in the range of 200 to 2000 frames/sec, is discussed. One msec resolution is obtained with a single neon glow lamp.

In an earlier article* the development of wide-angle optics to moderately high-speed motion-picture cameras by the Douglas Aircraft Co. was discussed. These scoring cameras were oriented in two clusters for spherical, binocular coverage in an aerial target to record missile miss vectors. From this development two main types of scoring cameras evolved, the Fastax and the Filmo. The Fastax version, made by the Wollensak Optical Co. of Rochester, N.Y., is a modification of the standard Fastax enabling it to operate smoothly at as slow a speed as 500 frames/sec. The Bell & Howell Filmo, intermittent film motion type, eventually culminated in a production model known as the Traid-200 Scoring Camera with a frame rate of 200 frames/sec. It is produced by the Traid Corp. (special California representative of the Bell & Howell Co. of Chicago), Sherman Oaks, Calif. Both types of cameras (see Figs. 1a and 1b) incorporate a comparatively large, but interchangeable, wide-angle optical assembly as shown in Fig. 1b (4 in. diameter by 8 in. long) with a field coverage of 142° and an aperture of about $f/1.5$. Figure 1a shows the new and smaller wide-angle lens assembly.

One of the main reasons for these rather large dimensions is the necessity of housing a circular bank of ten NE-51 glow lamps that constitutes a clock for time correlation. Nine of the lamps are pulsed in a syncopic binary code which gives a time resolution to within 1 msec and is generated by an electronic master time clock. The tenth lamp flashes for ground correlation on "event" time. These lamps are presented into the field of view of the objective lens of the wide-angle assembly and so are photographed simultaneously with each exposed field picture. With this system, in order to determine the time associated with a particular frame, it is necessary only to look up the binary equivalent in a glossary or to employ a decoding device.

The new timing device is divorced from the camera lens, being a separate system built directly into the camera. It consists of a single NE-16 neon glow lamp per camera that supplies essentially the same information derived from the ten lamps of the previous design. The electronic timer box that controls this lamp is smaller, simpler and lighter than the previous master time clock and can produce the same time and event accuracy *at* event time. The nine-lamp binary code system produces a precise clocking of an entire camera run and is used accordingly; but by proper synchronization of camera and incidence sequence a single-lamp timer can be programmed to pulse close to a short event, therefore providing a time record only when it is needed. An additional benefit of this simpler design is the freedom to use any lens on the camera.

There is a single neon glow lamp already installed in the Fastax camera, and it would be a relatively simple matter to modify its design to sharpen the lamp image on the film plane. The standard Fastax timer-lamp design incorporates a cylindrical lens that is used advantageously for higher frame rates. This specialized lens can be replaced by a simple achromat to increase the sharpness of the lamp image as required for this particular timing system.

The problem and also the main objective of the new development was to install a timer lamp in the Traid-200 camera. Because of the possible variations in the lengths of the film loops in this type of camera it is necessary to expose the image of the timer lamp on the film at the gate in order to assure that the time recorded is associated with a specific picture. Theoretically, it seemed at first that any type of pulse that could be exposed onto the film at this place would produce only a smeared garble of images; but, as it turned out, the intermittent motion of the film actu-

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(This paper was received on August 17, 1954.)

* H. E. Bauer and A. W. Blake, "Application of wide-angle optics to moderately high-speed motion-picture cameras," *Jour. SMPTE, 60:* 38–48, Jan. 1953.

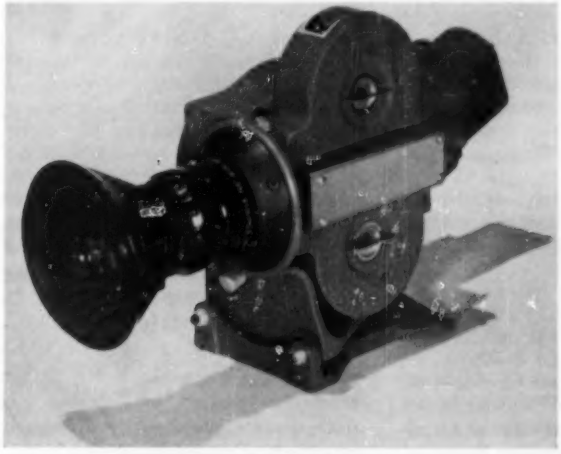

Fig. 1A. Traid 200 Scoring Camera.

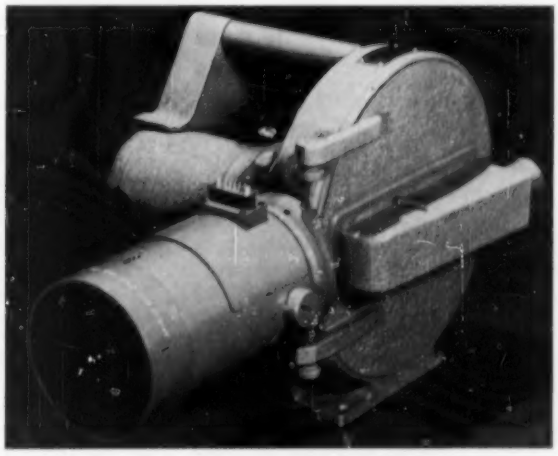

Fig. 1B. Fastax Scoring Camera.

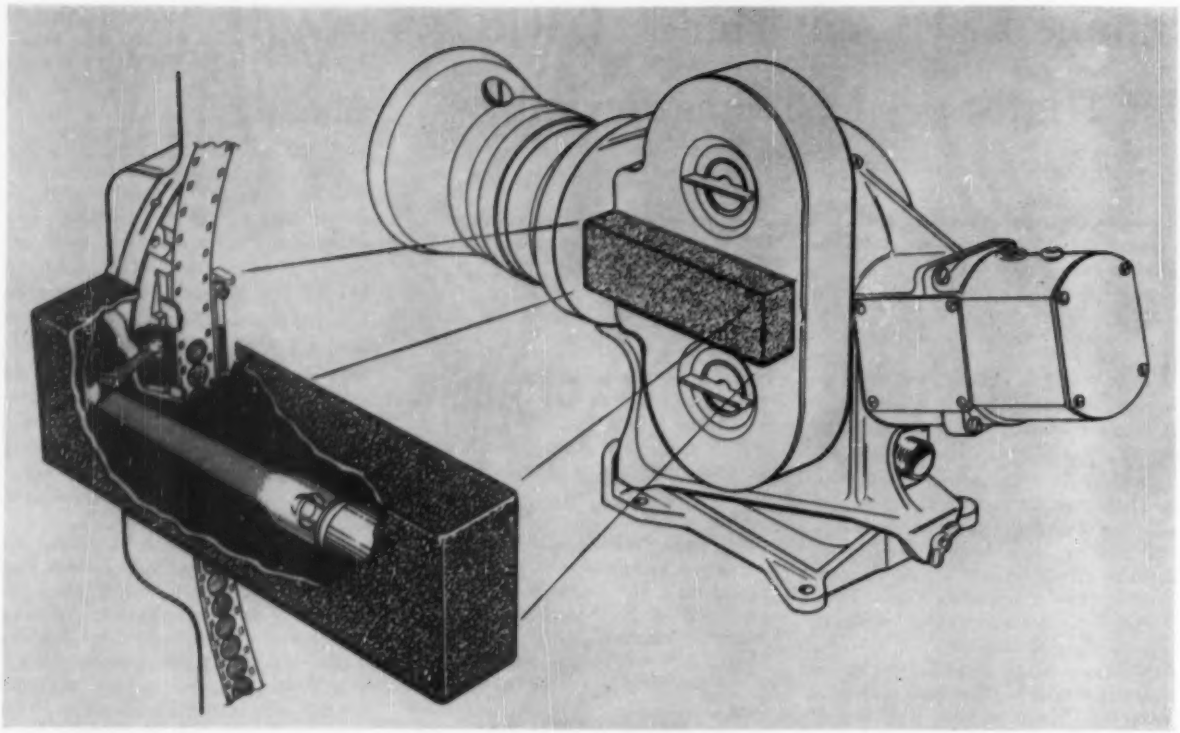

Fig. 2. Duplex Timer Installation in Traid 200.

Figure 3

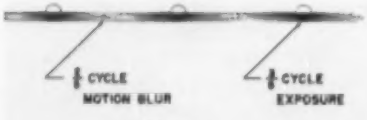

Figure 4

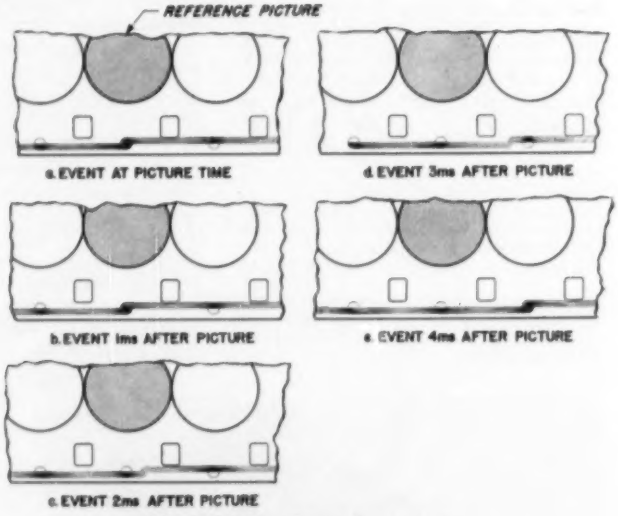
REFERENCE PICTURE
a. EVENT AT PICTURE TIME
d. EVENT 3ms AFTER PICTURE
b. EVENT 1ms AFTER PICTURE
e. EVENT 4ms AFTER PICTURE
c. EVENT 2ms AFTER PICTURE

Fig. 5. 200-fps picture time samples.

ally produced a periodic stationary and motion-blurred image pattern that is the key to a unique coding. It has been designated the "Duplex Timing System" and will be explained in greater detail.

Optical and Mechanical Design

The GE ¼-w NE-16 lamp is housed on the side of the camera door as shown in Fig. 2. The only place to project the lamp image on the film at the gate and not to obstruct the rays from a camera lens is on the very edge of the 16mm film outside the sprocket holes. In order to project the timer-lamp image onto the emulsion side of the film, the light path from the lamp has to be bent 180°. This is done with two mirrors, one of which is an integral part of a short focal length lens inserted in the optical path quite close to the film. The lens reduces the $\frac{5}{16}$-in. diameter electrodes of the lamp to the 0.030-in. diameter image needed at the film plane. To miniaturize the optics of the Duplex Timer as much as possible and to accomplish the demagnification needed, a prism lens was designed to be inserted between the shutter and aperture plate (a space of only $\frac{5}{16}$ in.). The possibilities for locating the lens are very limited, in fact confined to this particular location because the time code produced by the image of the timer lamp depends for its interpretation on the fact that it is continuously exposed on the film and not cut off by the rotating circular shutter. It also has to be positioned where

it would not interfere with the mechanics of the camera.

The prism lens is in reality a modified Coddington magnifier that is made from a cylindrical segment cut coaxially with an axis of a sphere of glass. The Duplex prism lens makes use of the same principle, but uses only a hemisphere of glass. The plane surface is used as a mirror reflecting plane and is aluminized because some of the refracted converging rays exceed the internal critical reflecting angle. This mirror surface is located 45° to the light path to bend, as well as to refract, twice through the convex surface of the glass hemisphere.

The principal points of a sphere of glass coincide at the geometrical center. This makes it simple to calculate the focal length and the location required for a particular magnification. Due to the confined quarters of the Duplex prism lens it was found impractical to provide a focusing adjustment; but, by judicious use of the formula, $f = nR/2(n-1)$, for the focal length of the Coddington lens, the image plane can be located by the proper choice of the index of refraction and by minor juggling of the radius. An effective focal length of 0.169 in. was chosen using glass of 1.588 index. The mount was designed so that the prism-lens has a working aperture of $f/1$.

Principles of the Duplex Code

The principles of the Duplex timing code are more easily understood once the exposure cycle of the Traid-200 camera is familiar. Figure 3 represents schematically the circular shutter and designates five arbitrarily oriented equal time segments of a picture cycle. Notice that during the picture cycle the film is stationary about three-fifths of the time and in motion the other two-fifths; i.e., at 200 frames/sec the film is stationary 3 msec and in motion 2 msec. At the end of the NE-16 neon glow lamp, a disk $\frac{5}{16}$ in. in diameter may be seen, that is split in half. These halves, separated by about $\frac{1}{32}$ in. glow singularly on the negative pole. If the lamp is oriented so that the image of the split is parallel to the direction of film motion, these two half electrodes form image paths on film that do not overlap, and if one of these electrodes were glowing steadily during a camera run, a pattern as shown in Fig. 4 would be produced after processing. Now, if the voltage polarity to the lamp electrodes were suddenly reversed electronically, this "switch" would produce a unique image pattern on film. The pattern is unmistakably different when the change occurs at different times during the exposure cycle. Assuming the camera to be running at 200 frames/sec, Figs. 5a, 5b, 5c, 5d and 5e represent consecutively, in 1-msec increments, the distinctly different patterns produced by the "switch" occurring at zero time (picture time) or any of the one-fifth segments thereafter.

The image pattern produced by a single polarity change records only an event time as received from an outside pulse. To determine the exact frame rate so that a base time scale can be laid down for consecutive picture frame evaluation, the lamp is switched back to the original polarity after a predetermined interval. One-tenth of a second was chosen as appropriate. There is nothing compelling about this selection except that the time duration had to be short enough for the Fastax with a continually changing frame rate and not too long for the slower intermittent camera, because this would entail too large a frame count.

The number of frames and fractions of frames can now be counted to determine the exact frame rate at event time. For example, if the leading end of the "flip-flop" pattern were as in Fig. 5b and the trailing end as in Fig. 5a with 18 full frames in between, then $\frac{4}{5} + 18 + 1 = 19.8$ frames in $\frac{1}{10}$ sec; which is 198 frames/sec, hence it takes 1000/198, or 5.05 msec per frame.

The question may arise at this time as to whether or not a single lamp being switched off at event time for $\frac{1}{10}$ sec could produce the desired code pattern. Earlier tests showed such a scheme would work but not with the assured accuracy that results from comparing two image ends in a "flip-flop" pattern. This comparative image, time selection, is used to the greatest advantage with Kodachrome film when evaluating the pattern change proximity of the film stationary segment of a picture cycle. This is because any variation of exposure that produces density changes in the developed image is more obvious when judging two images side by side. An isolated one can be judged, but it is less expedient when evaluating an event to determine whether it occurred before, during, or after a specific picture record.

Making use of two NE-51 glow lamps was also considered, but space limitations thwarted this approach to the problem. This narrowed the selection of a glow lamp down to the applicable electrode design of the NE-16 lamp.

This Duplex Timing System undoubtedly will also operate with continuous film flow cameras like the Fastax up to 500 frames/sec for Kodachrome and at least 2000 frames/sec for black-and-white film. As mentioned before, the cylindrical lens would have to be replaced by a small, short focal length, achromat lens to produce a sharp image on the film because a sharp break in the motion-blurred image is needed to divide it linearly into segments between picture frames. The image can be put on the film at the same place as the standard installation, i.e., 5 frames ahead of the picture being exposed.

Several frame rates of the continually changing film speed rate of the 16mm Fastax were studied. The greatest frame rate change in $\frac{1}{10}$ sec was found to be about 2%, which is within the accuracy usually required of such a timing system. This, of course, gives the average frame rate only during the measured $\frac{1}{10}$ sec following the event signal. To obtain a time scale for events of greater duration, the electronic control box could be changed accordingly. It could have a continuing "flip-flop" cycle of $\frac{1}{10}$ sec.

Electronic Controlling Equipment

The scope of this paper does not include any comprehensive description of the electronic control of the timing lamps, but it will be briefly described.

110-v, d-c power is applied to the NE-16 neon glow lamp through a series resistor that controls the intensity. The polarity of the voltage to the lamp is reversed almost instantaneously (within a few microseconds) by means of a switching amplifier which in turn is driven by a single-shot multivibrator. This multivibrator is set to $\frac{1}{10}$ sec duration, and tests have shown that it is possible to obtain this value to within 2% accuracy.

Film and its Limitations

To obtain the timing-lamp images and particularly the motion blur during the 2 msec of film transportation time on Kodachrome, it was found necessary to overload the lamp to 17 ma when running the Traid-200 camera at 200 frames/sec. (The time increment between two frames in the Fastax at 500 frames/sec is also 2 msec.) Concurrently, the prism lens was designed for a speed of $f/1$ so that as much brightness as possible is projected onto the film. When using black-and-white film, the power for the lamp is reduced to 7 ma to prevent overexposure. Switches are installed on the electronic control box to permit the correct light-intensity selection for the film used in each camera.

There is one precaution to be noted at this time. Daylight-loading, 100-ft spools of 16mm motion-picture film are not quite daylight-loading for this purpose. It was found that when loading the cameras in subdued daylight, the edges of the film (particularly black-and-white) were fogged at least half way into the spool in a path averaging about $\frac{1}{32}$ in. wide. This interfered with the Duplex code path. By loading the cameras in the darkroom with a Wratten Series OA safelight, this handicap is overcome.

Conclusions

The Duplex Timing System has proven

to be an accurate method of correlating time among several independent cameras. It will produce a time resolution of ±1 msec and give a ground correlation or "event" time. It is simpler, lighter and more economical than other systems used to this date.

The Douglas Aircraft Co. has applied for a patent on this device, and the Traid Corp. is currently manufacturing it under a license agreement.

Discussion

Anon (Edwards Air Force Base): In the timing system where you had lamps oriented in a circular bank that reflected off an annular mirror and thus back through the objective lens, what arrangement was made for determining time when the shutter was closed?

Mr. Blake: This circular bank of neon lamps is photographed simultaneously with each field picture. The shutter merely samples time at the same instance as the field picture exposure. By referring to a glossary of the lamp flashing pattern, the time of picture exposure can be determined.

Anon (EAFB): What happens to time in between pictures?

Mr. Blake: The lamp time clock being continuous, it is only necessary to sample it photographically at intervals.

Mark MacIntosh (Traid Corp.): In referring to the diagram showing the one-fifth segments of an exposure cycle, I would like to know whether at 100 frames/sec these segments become 2 msec long?

Mr. Blake: Yes, they would. The accuracy of the Duplex Code has the resolution of at least one-fifth the reciprocal of the frame per second. At 200 frames/sec this becomes 1 msec, and at 16 frames/sec, one eighth of a second.

motion-picture standards

Proposed American Standard PH22.100

A Proposed American Standard, Screen Brightness of 16mm Laboratory Review Rooms, PH22.100, is published on this page for the three-month period of trial and criticism. Comments should be sent to Henry Kogel, Staff Engineer, prior to April 15, 1955. If no adverse comments are received, this proposed standard will then be submitted to the ASA Sectional Committee on Cinematography, PH22, for further processing as an American Standard.

Some four years ago, the question was raised of standardizing the screen brightness of screens used in film processing laboratories when reviewing the quality of 16mm prints prior to shipping. Since then, surveys were conducted on existing field conditions and several different standards were drafted and voted upon by letter ballot by the Laboratory Practice and Screen Brightness Committees, but without obtaining the necessary unanimity of opinion. Two opposing views crystallized early: the majority held forth for and demonstrated the technical desirability of a screen brightness range of 9–14 ft L (the 35mm standard) whereas the minority proposed on a range of 5–10 ft L to permit certain limited projection conditions to fall within the range of the standard. The present proposal was an acceptable compromise to both groups.

Proposed American Standard

Screen Brightness of 16mm Laboratory Review Rooms

ASA Reg. U. S. Pat. Off.

PH22.100

1. Scope

1.1 This standard specifies the brightness of screens used in the projection of 16mm motion-picture prints in laboratory review rooms.

2. Screen Brightness

2.1 The brightness at the center of a screen for viewing 16mm motion pictures in laboratory review rooms shall be 10 ± 2 foot-Lamberts when the projector is running with no film in the gate.

NOT APPROVED

This draft was approved, almost unanimously, by the Screen Brightness, Laboratory Practice and Standards Committees with the exception of one negative vote from a member of the Laboratory Practice Committee.—*H.K.*

Three new American Standards of interest to SMPTE members are now available from the American Standards Association at 70 E. 45 St., New York 17:

(1) American Standard Method for the Free-Field Secondary Calibration of Microphones, Z24.11-1954.

(2) Method for Indicating the Stability of the Images of Processed Black-and-White Films, Plates and Papers, PH4.12-1954 (Revision of Z38.8.17-1948).

(3) Methods and Criteria for Determining the Chemical Resistivity and Photographic Inertness of Constructional Materials for Processing Equipment, PH4.13-1954.

news and reports

77th Convention Program

Special plans for the Spring Convention, to be held at the Drake Hotel, Chicago, April 18–22, include one or more sessions on Nontheatrical Motion Pictures and a Symposium on Screen Brightness.

The Convention Papers Programs are organized under the Society's Editorial Vice-President, an office now held for a second term by Norwood L. Simmons. Newly appointed Papers Committee Chairman is Ralph E. Lovell who is listed below, along with his Committee Vice-Chairmen. The procedure in recent years has been that the Vice-Chairman in a given area becomes the Program Chairman when the Convention is held in his area.

Any member or interested person is welcome to suggest papers, groups of papers or symposiums they would like to see on Convention Programs. Write to Society Headquarters or to any of those listed below. The complete roster of the Papers Committee for 1955 is not now available. It will be published in April, when the roster of all Society Committees is published. Present officers of the Committee and for this Convention are:

Ralph E. Lovell, *Chairman*, 2554 Prosser Ave., Los Angeles 64, Calif.

C. E. Heppberger, *77th Program Chairman*, 231 North Mill St., Naperville, Ill.

J. E. Aiken, *Vice-Chairman*, 116 N. Galveston St., Arlington 3, Va.

S. W. Athey, *Vice-Chairman*, General Precision Laboratory, 47 Ossining Rd., Pleasantville, N. Y.

Arthur C. Blaney, *Vice-Chairman*, Radio Corp. of America, 1560 N. Vine St., Hollywood 28, Calif.

John W. Ditamore, *Chairman, Nontheatrical Motion-Picture Papers Committee*, 822 N. Grant St., West Lafayette, Ind.

G. G. Graham, *Vice-Chairman*, National Film Board of Canada, John Street, Ottawa, Canada.

Fred J. Kolb, Jr., *Chairman for Symposium on Screen Brightness*, Manufacturing Experiments Div., Bldg. 35, Kodak Park, Rochester 4, N.Y.

Richard O. Painter, *77th Program Chairman for High-Speed Photography*, 738 East Liberty St., Milford, Michigan

J. H. Waddell, *Vice-Chairman*, Wollensack Optical Co., 850 Hudson St., Rochester 21, N. Y.

Two especially important regions which produce convention papers have long been served by special efforts by these Paper Committee Members:

Glenn E. Matthews, Eastman Kodak Co., Kodak Research Laboratories, Kodak Park, Rochester 4, N.Y.

Walter L. Tesch, Product Manager, Film Recording, Radio Corp. of America, Camden, N.J.

The Nontheatrical Motion-Pictures special aspect for this Convention has grown out of suggestions made by Philip A. Jacobsen, Technical and Research Director of the Motion Picture Unit at the University of Washington at Seattle. The Committee plans to obtain papers on educational, business and industrial films and their production. Three who are serving especially on this Committee with Mr. Ditamore are:

Herbert E. Farmer, Dept. of Cinema, University of Southern California, Los Angeles, Calif.

John Flory, Adviser on Nontheatrical Films, Eastman Kodak Co., 343 State St., Rochester 4, N.Y.

Kenneth M. Mason, Eastman Kodak Co., 137 North Wabash Ave., Chicago 2, Ill.

The Society's Screen Brightness Committee (p. 330 of the April 1954 *Journal*) will support Chairman Kolb for the Symposium.

engineering activities

SMPTE Engineering Committee activities are, for the most part, conducted by correspondence; the wide geographical dispersal of committee members makes it rather difficult to hold frequent committee meetings. The semiannual Society Convention, drawing together a scattered membership as it does, is a most opportune time for the committees to meet for a more direct exchange of ideas.

Nine engineering committees, as well as the ASA Sectional Committee on Cinematography, PH22, met at the Hotel Ambassador in Los Angeles, concurrent with the 76th Convention, during the week of October 18, 1954. Below, in capsule form, are presented the major deliberations and conclusions of these ten meetings:

Color

Various aspects of the taking and projecting of color motion pictures are under serious study by subcommittees formed to report on specific problems. H. W. Knop and W. R. Holm, Chairmen on two subcommittees, one on Projection Light Sources and Screens for Color Films and the other on Elements of Color Motion Pictures, reported progress in the preparation of monographs on these subjects. Plans for activating the subcommittees on Spectral Energy Distribution of Photographic Illuminants and on Standards of Light Quality in Color Film Projection were reported by the Chairmen, M. A. Sweet and A. M. Gundelfinger, respectively.

Film-Projection Practice

Three American Standards, 35mm Reels (Z22.4-1941), Theater Screen Dimensions (Z22.29-1948) and 35mm Sprockets (Z22.35-1947), were reviewed and agreement reached to begin revision of these three standards. In addition, plans were made to establish a subcommittee to collect and study all available information on devices and methods for reducing the temperature of film in the projector aperture.

High-Speed Photography

Progress was reported on preparation of a glossary of terms used in high-speed photography. Plans for future international high-speed symposia were noted and preparations were made for a supply of high-speed photography papers for the 77th Convention. The desirability of a committee newsletter to keep the members abreast of activities concerning one another was discussed and approved. The Chairman will issue such a newsletter whenever circumstances warrant.

Laboratory Practice

Revision of three American Standards, 16mm Contact Printing Aperture (Z22.48-1946), 35mm Reel Prints (Z22.55-1947) and Laboratory Nomenclature (Z22.56-1947), was initiated. Committee consideration on PH22.41, Photographic Sound Record on 16mm Prints, was terminated with the recommendation that it be submitted to the Standards Committee for further processing as an American Standard. Proposals for standards on (1) edgecuing of printer light changer and (2) printer aperture for CinemaScope were discussed and plans were made to initiate standardization.

Screen Brightness

Reports were heard from two subcommittees studying (1) unbalance in screen illumination and (2) screen brightness of drive-in theaters. The main discussion centered about these reports and plans for continuing these studies. Final arrangements were made for a Screen Brightness Symposium to be held at the next Convention in Chicago during the week of April 17, 1955.

16 & 8mm Motion Pictures

Changes in five American Standards were given serious consideration: 16mm Camera Aperture (Z22.7-1950); 16mm Projector Aperture (Z22.8-1950); 16mm Double Perforated Film, Usage in Camera (Z22.9-1946); 16mm Double Perforated Film, Usage in Projector (Z22.10-1947); and 8mm Reels (Z22.23-1941). The first two of these involved edge-guiding. Based on a recent study by Messrs. Chandler and Lyman, agreement was reached to ballot the full committee on revision of these two standards. The next two were concerned with rate of 16mm silent film travel through the camera and projector. Now that magnetic striping seems likely to be employed widely, 16mm "silent" projectors are not necessarily silent. Action on these two standards, under consideration for the last two years, was finally concluded and revised drafts are to be submitted to the Standards Committee for further processing. Proposed revision of the 8mm reel standard was approved for letter ballot of the full committee. In addition, further study of a test film for 8mm projectors and standardization of a 16mm reel was initiated.

Sound

Two test film standards, 35mm Sound Focusing (Z22.61-1949) and 35mm Buzz Track (Z22.68-1949), were reaffirmed without change and are to be submitted to the Standards Committee for further processing. In addition, exploratory talks were held on standardization of perspecta sound, the status of studies on the absolute measurement of magnetic level was reviewed and the quality of the existing four-track CinemaScope test film was investigated and found adequate.

Magnetic Recording Subcommittee

One proposed standard, 35mm Magnetic Azimuth Checking Test Film, was withdrawn since this specific test film is no longer needed. A new proposal was initiated establishing the separation between the picture and corresponding sound for 16mm film employing magnetic sound recording. A report was made on the status of the studies made by the Navy on the absolute measurement of magnetic level; this report is to be distributed to all members of the subcommittee. Plans were made for the production of some experimental footage of 16mm azimuth test film of the 1000-pulse, 140-μsec dimension variety. This film is to be distributed to the committee for consideration as a desirable method of setting azimuth.

Television

This group was primarily concerned with concluding the arrangements for the production of a test film and test slides for color television. Every effort is being made to make this test material available within the first few months of 1955.

PH22

This meeting was called for the purpose of reviewing the status of the international standardization program and to establish the United States position as to the participation in and calling of a special meeting of ISO/TC 36 Committee on Cinematography for June 1955. The conclusion was reached that the United States would not request the arrangement of such a meeting by ASA as Secretariat for the ISO committee but would cooperate in the formation of a delegation to attend a meeting, if there is sufficiently widespread interest on the part of the other members in having one called.

International Standardization

The ASA, as Secretariat, canvassed the members of ISO/TC 36, Cinematography regarding their interest in participating in a June 1955 meeting. The response was overwhelmingly in favor and it was therefore decided to call a meeting of this committee in Stockholm, Sweden, sometime during the period of June 6 to 18, 1955. Preparations are now being made to form the United States delegation and to establish the items the United States would like to have on the agenda.—*Henry Kogel*, Staff Engineer.

Biographical Note

Dr. Alexander Ernemann, General Manager of Zeiss Ikon A.G., has just celebrated the completion of his fiftieth year in the motion-picture industry. When Dr. Ernemann went to work in his father's factory in 1904, 17.5mm film with center perforations was in use and projectors were of brass with wooden housing. Ernemann early traveled to the U.S. and as a result of experience gained on his travels began to manufacture an all-metal projector, the Ernemann Imperator, which continued to be a standard projector until well after the First World War.

In commercial cooperation with Krupp, of Essen, Ernemann put out the first German sound film projector in 1925. Since 1926, when the firm of Zeiss Ikon A.G. was organized, he has been associated with that company, year after year bringing out his numbered series of Ernemann projectors. The latest of these to appear from the Kiel plant, to which Zeiss Ikon moved from Dresden after World War II, is the Ernemann X, which incorporates a magnetic sound reproduction unit.

section reports

The Central Section held its last meeting of 1954 on December 13 in the United Airlines building at Midway Airport. Approximately 100 people listened to J. E. Sandow, Chief of Flight Training at United Airlines, discuss the operation of the Dehml training unit for training airline pilots. This apparatus constructed by Douglas provides very impressive simulated flight for pilot training along with all possible emergency situations. Actual demonstration of the training unit was conducted by two United Airlines pilots. Coffee and doughnuts were served following the meeting.

At the pre-meeting Board of Managers session, the three new managers recently elected in the Central Section were welcomed. These are: D. W. Ridgway, Encyclopaedia Britannica Films; R. G. Herbst, Bell & Howell Co.; and J. C. Diebold, Wilding Picture Productions. Preliminary plans for the 77th Semiannual Convention in Chicago were discussed.—*Kenneth M. Mason*, Secretary-Treasurer, c/o Eastman Kodak Co., 137 N. Wabash Ave., Chicago 2.

The Southwest Subsection election results have been announced by I. L. Miller, with the following officers elected for 1955 and Managers for 1955–56:

Ernest D. Gaw, Chairman
Orville H. Mills, Secretary-Treasurer
Bruce Howard, Manager
Wm. H. Carter, Jr., Manager

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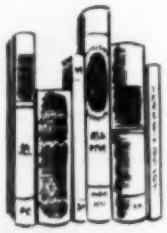

The Theory of the Photographic Process, Revised Edition

By C. E. Kenneth Mees. Published (1954) by Macmillan Co., 60 Fifth Ave., New York 11. i–x + 1133 pp. 416 illus. 6 × 9 in. Price $21.50.

The long awaited revision of this standard reference work has now appeared, and it is evident that this much used contribution to the photographic literature has been greatly extended, with a thorough coverage of the intervening 12 years since original publication. All chapters and sections have been thoroughly rewritten and in general improved, in part due to the fact that the information available is more complete at present. New chapters have been

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included on such subjects as the latent image produced by x-rays, the sensitometry of color films and papers, and the effects of charged particles on photographic emulsions. The wealth of new material, in addition to whole new sections, has made it necessary to omit some of the historical material and to delete the chapter on the Photographic Aspects of Sound Recording. Motion-picture engineers will miss this, but more detailed specialized references are available, and it is not of as general interest as the rest.

Since this book is expensive, it is important for motion-picture engineers to realize how useful it is, and why it is well worth acquiring.

The book is well described by Dr. Mees in his preface to the first edition, reprinted in this edition, in which he says "The purpose of this book is to provide a general handbook of the subject as a guide to the literature and a summary of its conclusions." As an annotated bibliography covering practically the entire literature of the science of photography, this book is unique and could only be produced by a man having access to the tremendous laboratory personnel of the Kodak organizations. As far as its impact upon the science of photography is concerned, it is probably the most valuable contribution Dr. Mees has made. When it is realized that this reference work gives the general conclusions of all theoretical and much practical work in the whole science of photography, and then refers to the original literature for more details, it will be realized how important and useful it is to have constantly available. The omissions are few and far between; mostly of late data which became available after some particular parts of this book were completed. The volume is a treatise in the strict sense, usable as an encyclopedia, but of course it does not give the complete story on each subject, which would be impossible in this small compass. It is obvious that it cannot be read casually, but must be read with thought and attention. The well over 2100 references give us the chance to go to the original data to form our own conclusions, helped of course by Dr. Mees' experienced comments.

The great quantity of new material added in this edition is evidence of the fact that all phases of the science of photography have been actively studied during this period. There are yet cases where the review must state, as on Page 530, "No general agreement on the mechanism of development has been reached," after the several possible mechanisms are dealt with in adequate detail for most purposes; where further data are needed an exhaustive study such as that of James & Higgins or the original papers can be obtained.

As a text book, this volume will be necessary in schools teaching any aspect of the science of photography, but of course it is a reference text only since it is not intended as an instructional manual. It differs from other works covering much the same ground such as those of Clerc, Mack and Martin, and others which cover a little of the theory and a great deal of the practice. Here very little practice is to be found.

A few very recent items might be mentioned for those who wish to know how late the coverage is. For instance, there is no reference to the work of Andre Rott and his diffusion-transfer reversal processes and little mention of combined developer-fixer solutions. The recent work of Dr. LuValle in photographic theory and analysis of solutions has been available too recently to include. There is only slight mention of the pyrazolidones, which are now the subject of so much activity, and no mention of a few new developing agents such as 8-Hydroxy 1,2,3,4 Tetrahydroquinoline, nor of the work of such groups as that under Dr. MacDonald on various aspects of photographic resolution and image sharpness. The obvious omission of data on emulsion making is explained in the preface as referring to data he is not entitled to publish with frankness.

It is a pleasure to see the full credit given to the original workers and authors of papers to which Dr. Mees refers, and also his acknowledgment of the help given him by the members of his own organization whose names are now given in the table of contents, with reference to the chapters which they specifically contributed. In general, it is a remarkably complete and useful book, full of information for any engineer or scientist working in photography. Its usefulness as a reference is helped by the frankness with which Dr. Mees expresses his own opinions, in contradistinction to those of the authors to whom he refers.

The investment in this book is highly recommended not only to laboratories and libraries, but to the individual worker who will seldom find so much information avail-

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able in such a short space; information which it will take him a very long time to assimilate.—*Thomas T. Hill*, Director, Photographic Research, Philip A. Hunt Co., Palisades Park, N.J.

Staging TV Programs and Commercials

By Robert J. Wade. Published (1954) by Hastings House, 41 E. 50 St., New York 22. 232 pp. 100 illus. 6¼ × 9¼ in. $6.50.

As in his previously published books on related subjects in the field of television production, Mr. Wade's concentration on the practical aspects of his trade results in a highly readable volume which is sure to become the standard reference work in solving the physical staging problems of "live" TV programming.

The attention to specific detail is one of the book's principal qualities, and it is evident in its careful planning and intelligent approach. The illustrations are of the widest variety, running from stills to diagrams, floor plans, blue prints and cartoons.

The body of the text scrutinizes the kindred activities of TV staging, dissecting in turn production facilities, scenic design, construction and painting, lighting, props, graphics, and special effects. An index and a suppliers' list round out this most informative work.—*George L. George*, Sturgis-Grant Productions, Inc., 322 E. 44 St., New York 17.

The Television Commercial

By Harry Wayne McMahan. Published (1954) by Hastings House, 41 E. 50 St., New York 22. 192 pp. 109 illus. 6¼ × 9¼ in. $5.00.

In the highly competitive field of television "spot" advertising, efficiency of production is the basic asset of success. Mr. McMahan's experience in this specialized domain has led him to write a most practical book devoted to this subject, which both producers and users of TV commercials will welcome.

After listing the five production techniques available for TV film spots, (i.e. cartoon, live action, stop motion, puppets, photo animation), the author examines each one in detail from the points of view of the product involved, the selling angle, and the financial cost.

The discussion of these various problems is lively, often provocative, and always well informed, with a striking use of stills from actual "spots."—*George L. George*, Sturgis-Grant Productions, Inc., 322 E. 44 St., New York 17.

Introduction to 3-D

By H. Dewhurst. Published (1954) by The Macmillan Company, 60 Fifth Ave., N.Y. xv + 152 pp. 57 illus. 5½ × 8½ in. Price $4.50.

It is very difficult to evaluate this volume objectively. The sentence structure is so tortuous that it frequently succeeds in obscuring the meaning.

From page 10: "Regarded on its own merits as an isolated factor amongst those which we have classed as monocular, accommodation probably plays but a small part in supplying crucial information in the sum total of that upon which the brain arrives at its synthesis of depth awareness from the evidence of the various factors received." If you are puzzled by this, it probably means: "Accommodation seems to be only a minor factor in depth awareness." The latter is eleven words long as against fifty-three in the text.

On page 12: "In essence we are stating that in seeking a suitable definition of the word, our immediate purposes are served if we regard 'perspective' as the drawing-in of the intersection of all light rays from the scene to the eye upon a plane at right angles to the center line of sight, and we have seen that the perspective of the elements within a scene will be different if the distance of this plane from the eye or lens be changed."

This, besides being an example of style of writing, also lacks technical preciseness, to the point of obscurity. Does a perspective have to be on a plane at right angles to the center line of sight? If the eye does not move nor the scene change, a sheet of glass placed anywhere between the two will not alter the perspective one iota. Yet the quoted statement says that the perspective will be different if the position of the picture plane is changed.

These random examples — any page will yield others — should illustrate the difficulty of reading the book with any degree of pleasure or of certainty as to meaning.

From the stereoscopic point of view the author seems to me to accept too many of the standard notions about three-dimensional pictures without critically questioning their validity. The following paragraph (from p. 40) is the heart of the matter:

"The inescapable geometrical requirements of a satisfying projection, whatever the viewing-aids, projection methods and individual projection systems may be that are employed, are four in number. Firstly, let us state these, and afterwards examine how they are to be achieved. They are: (i) the prevention of too severe a departure from the convergence accommodation ratios that we are accustomed to in normal vision; (ii) the prevention of 'divergence,' that is to say, a splay-out of the 'infinity points'—to be explained in a moment; (iii) the establishment on the screen, or rather 'in' the screen, of a definite 'window,' with well-defined and merging side-borders, *through* which the three-dimensional reconstructed scene is more often than not to be viewed; and (iv) the avoidance of too marked a departure, in the viewed image, from that natural depth which is associated with the original scene. Let us take these four requirements in order and see what they imply."

Note to begin with that we are getting "*inescapable* geometrical requirements of a *satisfying* projection." That is, physical requirements for an aesthetic reaction. These, therefore, are not the requirements for an orthostereoscopic image but for a satisfying image.

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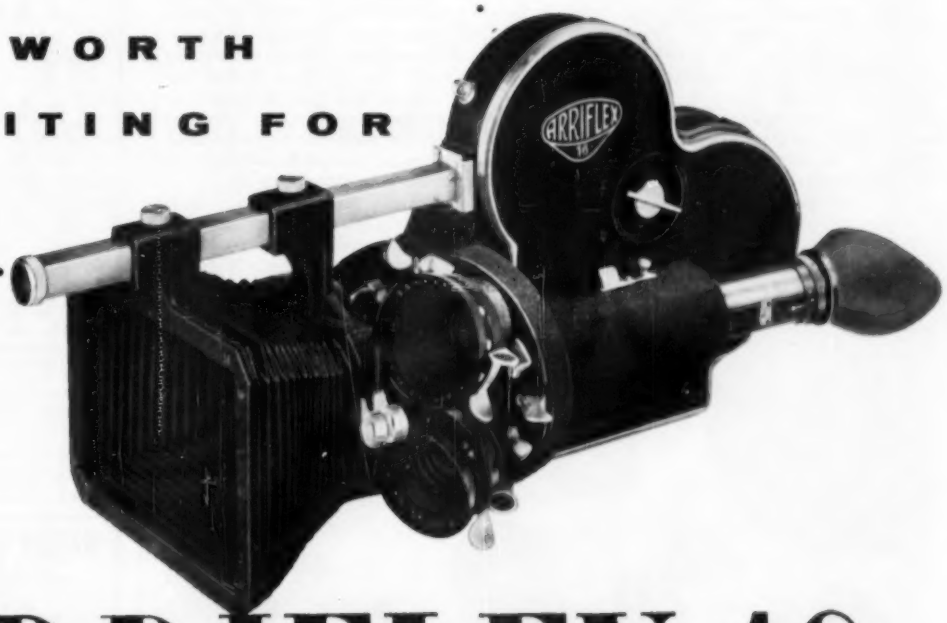

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for an orthostereoscopic image but for a satisfying image.

I have no quarrel with (i). Eye-strain is never satisfying.

I do quarrel with (ii). Most of us involved in stereo projection accepted this as gospel until the recent Hollywood splurge in 3-D. It has become quite clear, however, that most eyes will comfortably tolerate much more divergence than was hitherto suspected. Divergence adds depth. To some persons depth is "satisfying." Though much more experimentation is needed in this area, "prevention of divergence" is certainly not an "inescapable geometric requirement"—assuming, of course, that prevention could be a geometric requirement under any condition.

I disagree with (iii). Of course a sharp window with well defined borders is, in the present state of the art, the best way to handle the edges of a stereo picture, but there is nothing inescapable about it. If Cinerama were made stereo, a fading off at the edges might prove better. Certainly there is no reason at all that the window should be 'in' the screen. When the screen texture becomes really invisible, the spectator cannot locate the screen at all and the window may be in front or behind the screen so long as, in general, it remains in front of objects in the scene. Furthermore, a window built into the scene itself provides an excellent solution, as the author himself admits only three pages later.

I disagree with (iv) completely. It is on this score that I would quarrel with most current stereo literature. Spottiswoode in general falls into the same trap. Of course it is of great importance to know the ge-

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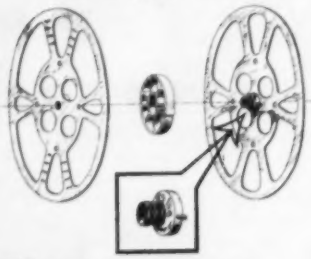

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ometry of obtaining a stereo image which is exactly the size, shape and location with respect to the eyes as the original scene. But to state that this is an "inescapable geometrical requirement of a satisfying projection" is not only sheer nonsense, but it at once destroys any possibility of treating stereo as an art.

Pictorial art in all its forms is the process of altering reality to make it aesthetically more meaningful or, if you will, more satisfying. Under certain conditions exaggerated depth is far more satisfying than the original — under others, flattened depth. Certainly the ability to alter shape and location is the heart and soul of stereo's creative, artistic possibilities. The difficulty of obtaining accurate reproduction may be a defect where you must have accurate reproduction. However, we should keep forever before our eyes that the true future of stereo lies in its ability to remold spatial reality. Let us abandon this obsession with true shape and at least begin to explore the aesthetic possibilities of the various possible departures from it.

On the same score, the author assumes as Spottiswoode does that giantism and miniaturism are, per se, bad. In some circumstances they are, but in others quite the contrary may be true. They are tools in the photographers kit that may be used effectively under proper conditions and should be viewed as such.

After developing the theory of stereo photography and projection, the author surveys all the current systems and their resulting equipment. This yields a valuable picture of the various mechanical devices in existence for solving stereo problems. The author seems to me to be much more at home with equipment than with theory, though the same tortured sentences mar the text. Thus the value of the book lies chiefly in its supplying a ready source for checking up on current systems and equipment.—*Prof. John T. Rule*, Massachusetts Institute of Technology, Cambridge, Mass.

Commercial Motion Picture Production Accounting is the title of a paper by Ben Dyer published in the March 1954 issue of *The New York Certified Public Accountant*. While it is a little off the well-beaten tracks of equipment techniques, this subject is nevertheless one which will undoubtedly interest many technical people around the studios and production companies, and published material on it is relatively rare. This paper distinguishes commercial from theatrical production and outlines approaches common to all commercial producers; contracting procedures; script analysis; cost estimating; contracts, schedules and controls. The author tries: ". . . to cover those phases not found in other business and to show that, although both theatrical and commercial producers use the same techniques, the same equipment, the same unions, the same materials, etc., theatrical production is speculative but commercial production is a highly competitive contracting business. And that, while theatrical production costs bear little relation to its profits, commercial production costs directly affect its prices and profits."

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Managers and heads of recording departments from some of Westrex Corp.'s subsidiaries in Europe, Africa, Australasia and Latin America attended a conference in New York, November 8–19. The conferees discussed new equipment operational techniques and surveyed Westrex sales and servicing activities in motion-picture studio and theater equipment fields, as well as Teletype, Teletypesetter, communications and other electronic apparatus. New equipment displayed at the conference included single and multichannel sound systems for theaters, a film editing machine, multichannel magnetic recording systems, the type RA1524 six-position mixer console, the 35 mm newsreel recording system, the new re-recorders, electrical printing equipment, the new hot-stylus lateral feedback disk cutter, and the new black-and-white and color densitometers for studios.

In the picture above, E. S. Gregg, President of Westrex Corp., is showing the firm's new multichannel amplifier system to, from left to right: J. A. Todd, recording manager of the Westrex Co. Ltd., England; J. Cuevas, manager of the Westrex Co., Brazil; J. Y. Abe, director and assistant manager of the Westrex Co., Orient, Japan; P. Amourgis, manager of the Westrex Co., East, Egypt; R. Senechal, head of recording department of the Westrex Co., France-Belgium, France; M. Storms, II, manager of the Westrex Co., Caribbean, Venezuela; behind R. J. Hortis, manager of the Westrex Co., Argentina; W. E. Kollmyer, manager of the Westrex Australia Pty., Ltd., behind K. Kagara, recording engineer of the Westrex Co., Orient, Japan; O. J. Forest, manager of the Westrex Co., Caribbean, Trinidad; W. De Mello, manager of the Westrex Co., Caribbean, Cuba; and C. Adlerstrahle, manager of the Westrex Scandinavia, AB, Sweden.

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current literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

Acoustical Society of America, Journal
vol. 26, Sept. 1954

Loudspeakers and Microphones (p. 618) *L. L. Beranek*

A Review of Twenty-Five Years of Sound Reproduction (p. 637) *H. F. Olson*

Sound Systems for Large Auditoriums (p. 661) *L. L. Beranek*

American Cinematographer
vol. 35, Sept. 1954

MGM's New Underwater Camera Blimp (p. 440) *A. Rowan*

He Makes News Live (p. 442) *J. F. Palmer*

Sync Sound Without Interlock (p. 445) *F. Harris*

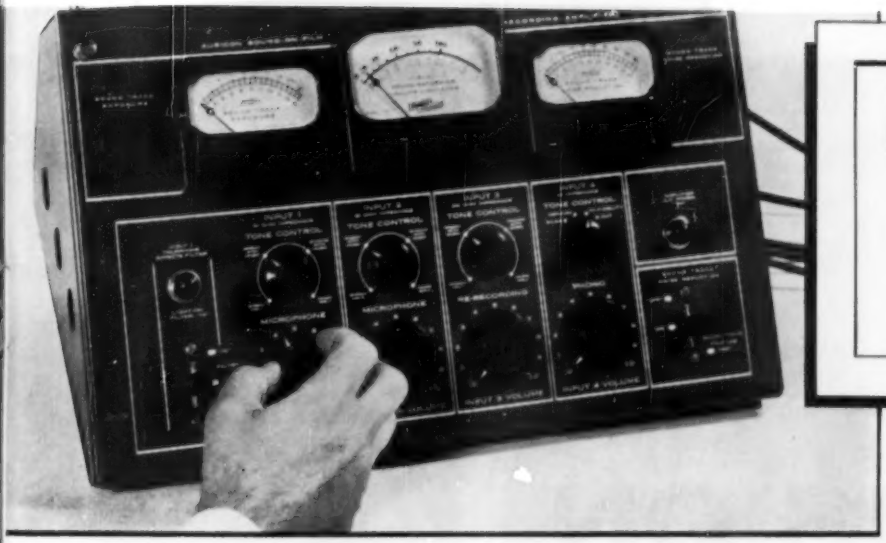
Hank McCune TV Series Filmed in 16mm Color (p. 446) *F. Foster*

High-speed Filming of Instrument Action (p. 448) *A. D. Roe*

Radio Controlled Cinematography (p. 450) *J. W. Bakke*

High-speed Film Processor (p. 451)

Is Your 16-millimeter Camera Showing Its Age (p. 452) *H. Stockert*



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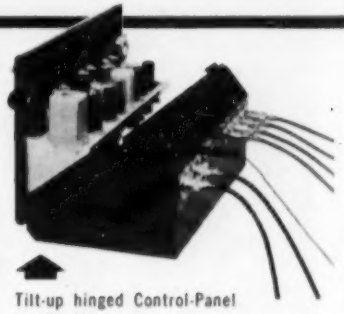

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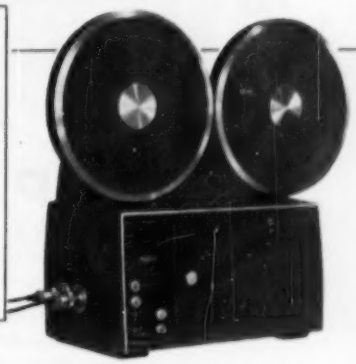

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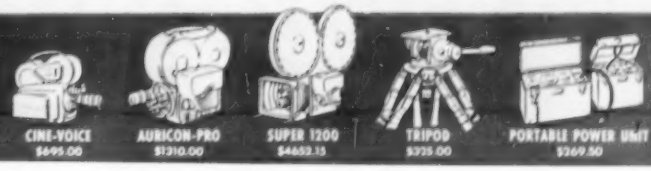

vol. 35, Oct. 1954

Todd-AO—Newest Wide-Screen System (p. 494) *A. Rawan*

How to Edit 16mm "A" and "B" Rolls (p. 498) *J. Forbes*

A Remote Control for 16mm Stop-Motion Photography (p. 450) *J. Hoke*

FilmoRama—CinemaScope in 16mm (p. 504) *L. Allen*

vol. 35, Nov. 1954

VistaVision Moves Forward (p. 552) *L. L. Ryder and J. Bishop*

Effecting Economies in the Editing of TV Films (p. 562) *H. R. Cohen*

British Kinematography vol. 25, July 1954

Microwave Transmissions to Cinemas (p. 8) *T. M. C. Lance*

The Carbon Arc as Applied to Wide Screen and 3-D (p. 20) *H. P. Woods*

vol. 25, Aug. 1954

Current Developments in Film Presentation (p. 41) *A. Bowen, J. Moir and F. A. Tuck*

Improvement in the Sharpness of Colour Images (p. 56) *L. A. Meeussen*

Electronics vol. 27, Sept. 1954

Color Video Tester Checks Distortion (p. 128) *H. P. Kelly*

vol. 27, Nov. 1954

Color Test Techniques for TV Broadcasters (p. 120) *J. W. Wentworth*

Film Technikum vol. 5, Sept. 1954

Elektroakustische Grossanlage (p. 208)

Freilicht-Projektion auf 243 qm Bildfläche (p. 213) *D. B. Sasse*

Stand der Bild- und Tontechnik im Theater und Filmstudio (p. 216)

Functional Photography

vol. 6, No. 1, Oct. 1954

Three-Colour Television Tubes in the Making (p. 12) *M. Lorant*

The Ideal Kinema vol. 20, Sept. 9, 1954

Improved Optics and More Light the Keys to Wide Appeal (p. 17) *R. H. Cricks*

Institute of Radio Engineers, Proceedings

vol. 42, Oct. 1954

Beam Deflection Color Television Picture Tubes (p. 1478) *J. M. Lafferty*

Characteristics of a Transmission Control Viewing Storage Tube with Halftone Display (p. 1496) *M. Knoll, H. O. Hook and R. P. Stone*

International Projectionist vol. 29, Aug. 1954

An Evaluation of Optical Sound (p. 7) *R. A. Mitchell*

The Optics of CinemaScope (p. 10) *R. Altman*

vol. 29, Sept. 1954

Screen Light with Various Projection Aspect Ratios (p. 7) *C. A. Hahn*

Carbon Arc Requisites for the New Processes (p. 9) *H. P. Woods*

Light Requirements for Wide-screen Projection (p. 12) *A. J. Hatch*

Your Guide to Proper Lens Selection (p. 16) *M. D. O'Brien*

An Evaluation of Optical Sound (p. 21) *R. A. Mitchell*

Past, Present—and Future (?) (p. 23) *M. Chamberlain*

Perspecta Sound Operational Data (p. 26) *M. Stephens*

vol. 29, Oct. 1954

The New Kollmorgen F/1.7 Lens (p. 12) *M. Stevens*

The VistaVision Horizontal Projector (p. 16) *J. Morris*

An Evaluation of Optical Sound (p. 22) *R. A. Mitchell*

Journal of Physical Chemistry

vol. 58, Oct. 1954

Colloidal and Surface Phenomena in the Preparation of Cathode-ray Screens (p. 812) *J. F. Hazel and G. L. Schnable*

Motion Picture Herald

Vol. 197, No. 5, Oct. 30, 1954

Projection of a VistaVision Print with 1.418 Frame (p. 32) (illustrated on p. 14 of regular section)

Data for Sizing Picture with Any Projection System (p. 22) *G. Gagliardi*

Philips Technical Review vol. 16, July 1954

An Experimental Photoconductive Camera Tube for Television (p. 23) *L. Heijne, P. Schagen and H. Bruining*

Secondary Emission from the Screen of a Picture-Tube (p. 26) *J. de Gier, A. C. Kleisma and J. Peper*

Radio & Television News vol. 52, Sept. 1954

Fundamentals of Color TV. Color Synchronization (p. 42) *M. S. Kiver*

vol. 52, Oct. 1954

Fundamentals of Color TV; Deflection and High Voltage (p. 64) *M. S. Kiver*

vol. 52, Nov. 1954

Fundamentals of Color TV. R-Y & B-Y Demodulation Systems (p. 63) *M. S. Kiver*

RCA Review vol. 15, Sept. 1954

Television Transmitter Considerations in Color Broadcasting (p. 312) *T. M. Gluyas, Jr.*

Monochrome Vidicon Film Camera (p. 372) *W. L. Hurford and R. J. Marian*

The CT-100 Commercial Color Television Receiver (p. 445) *L. R. Kirkwood and A. J. Torre*

Tele-Tech and Electronic Industries

vol. 13, Oct. 1954

Tube Selection Increases Signal Capacity of TV Receivers (p. 70) *R. G. Horner*

Transistor Reliability in Low Power Audio Uses (p. 77) *F. M. Dukat*

Automatic Production of TV Sets (p. 79)

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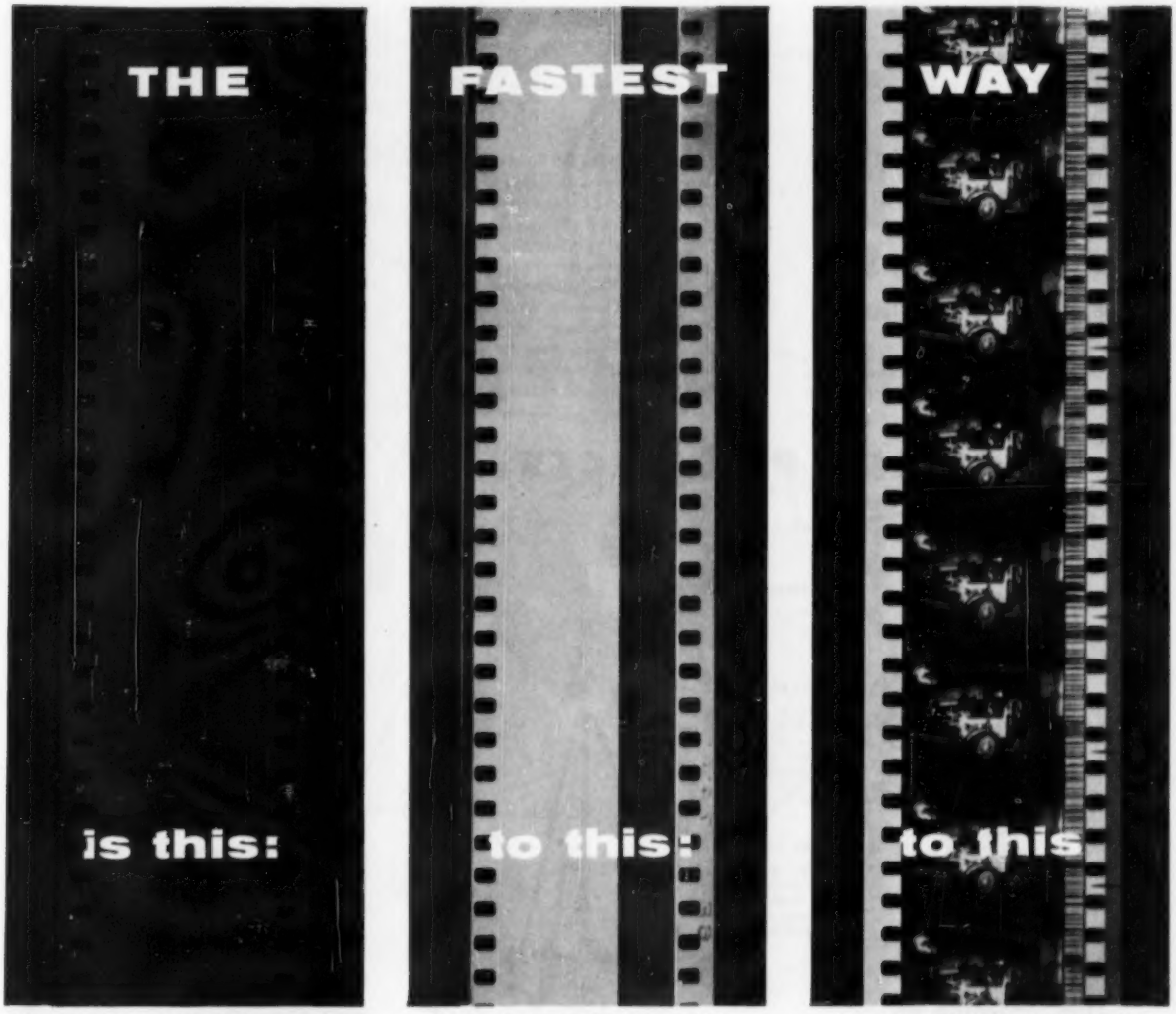

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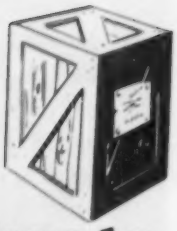

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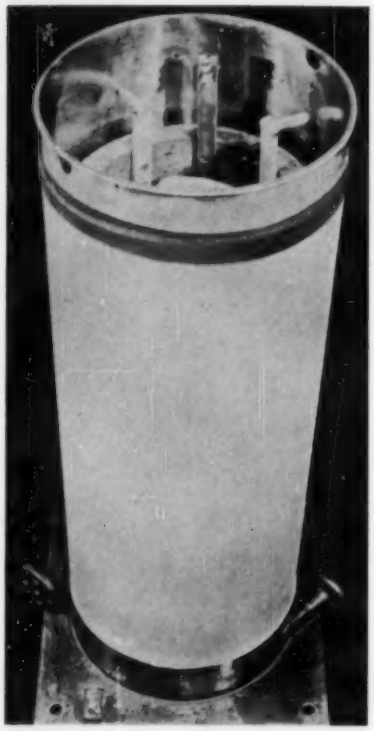

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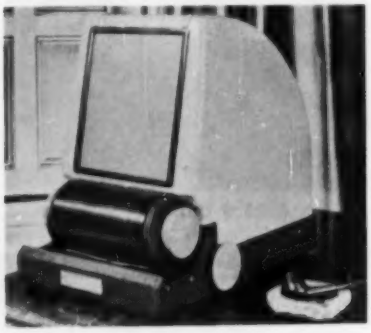

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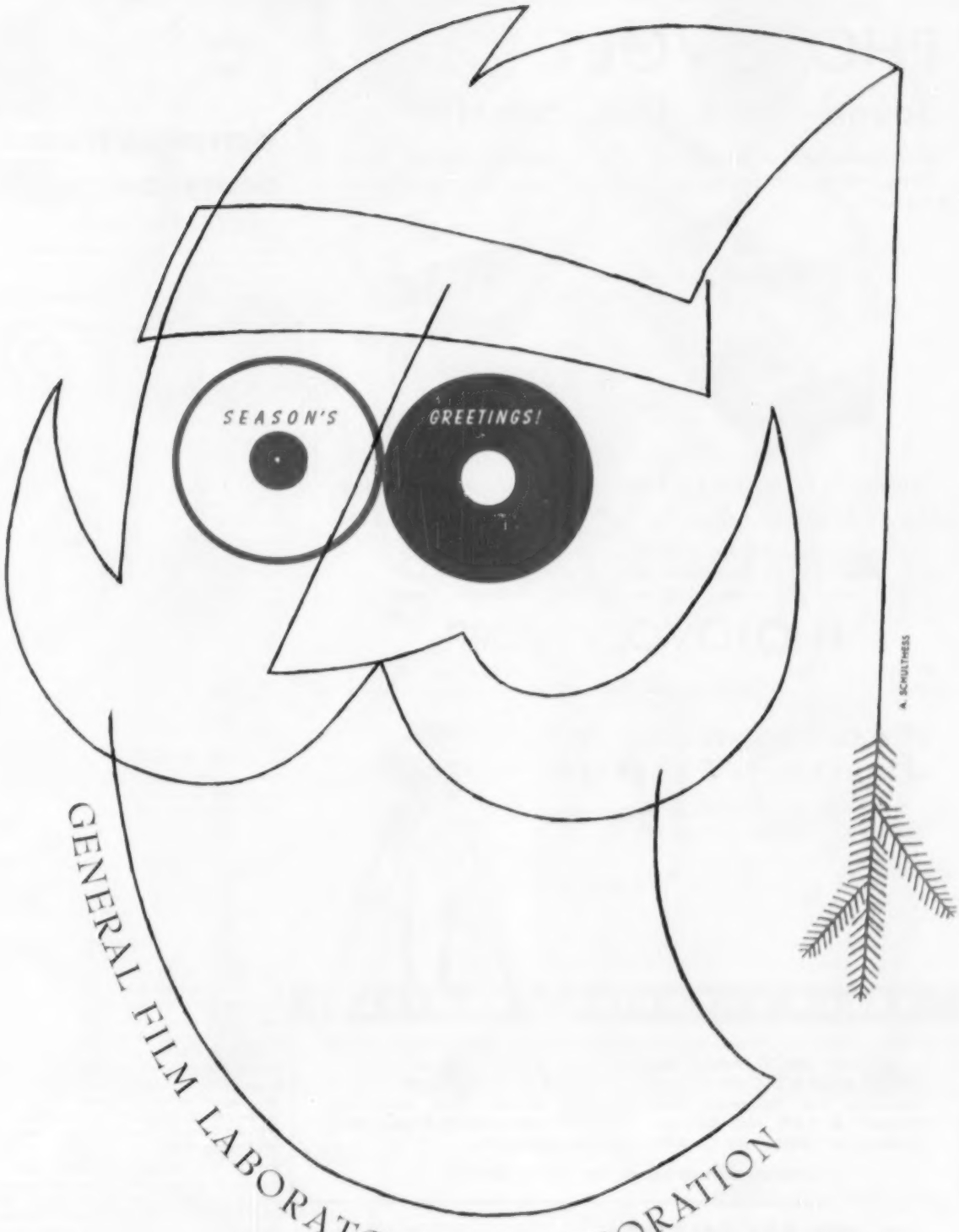

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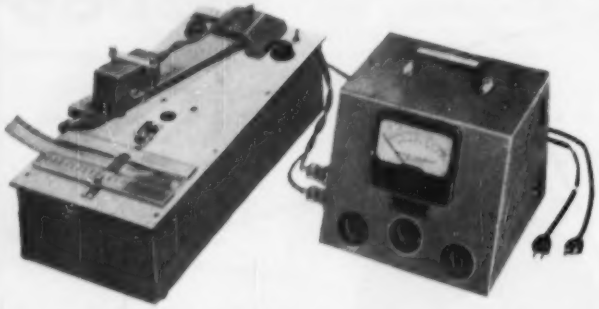

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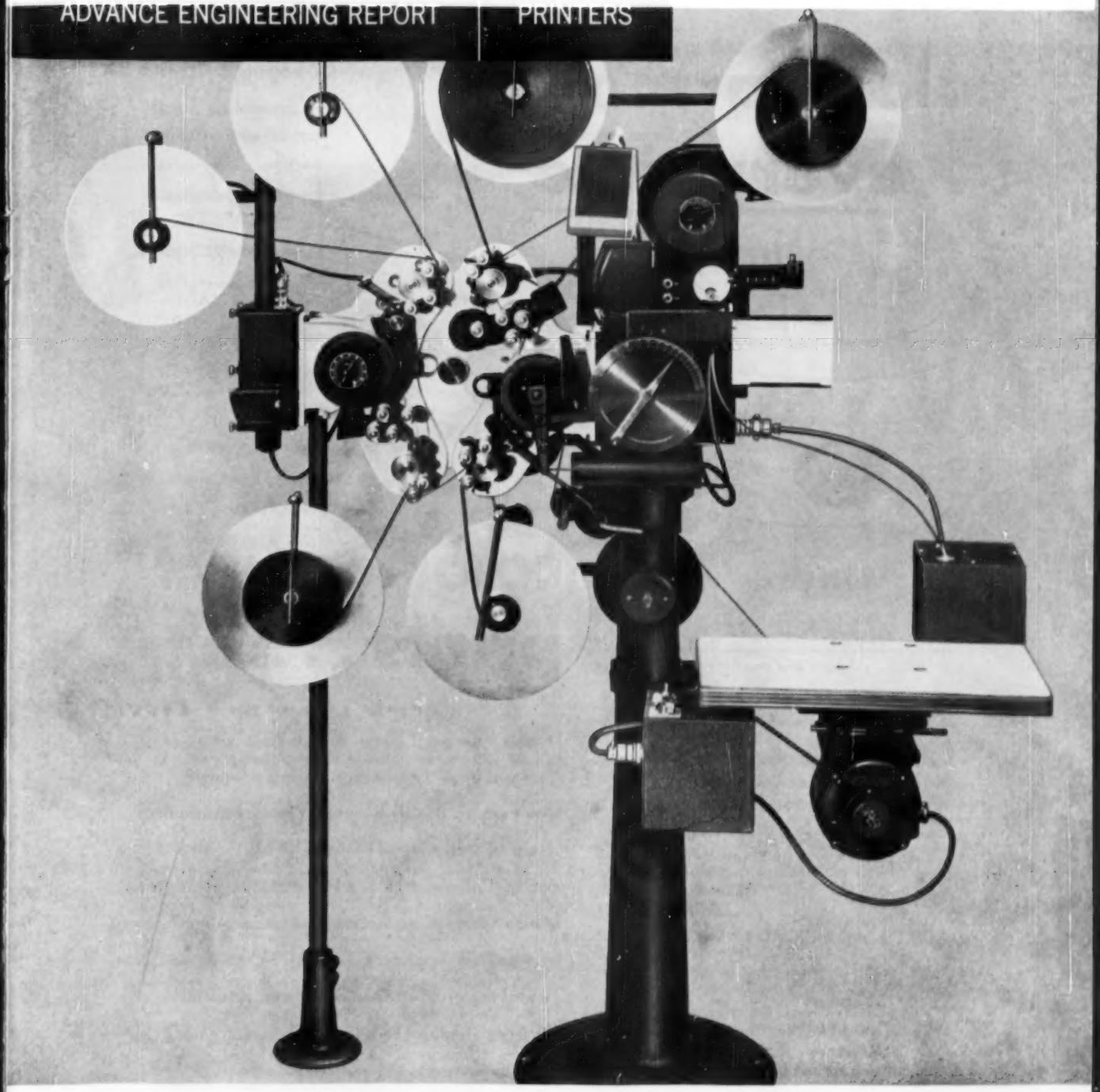

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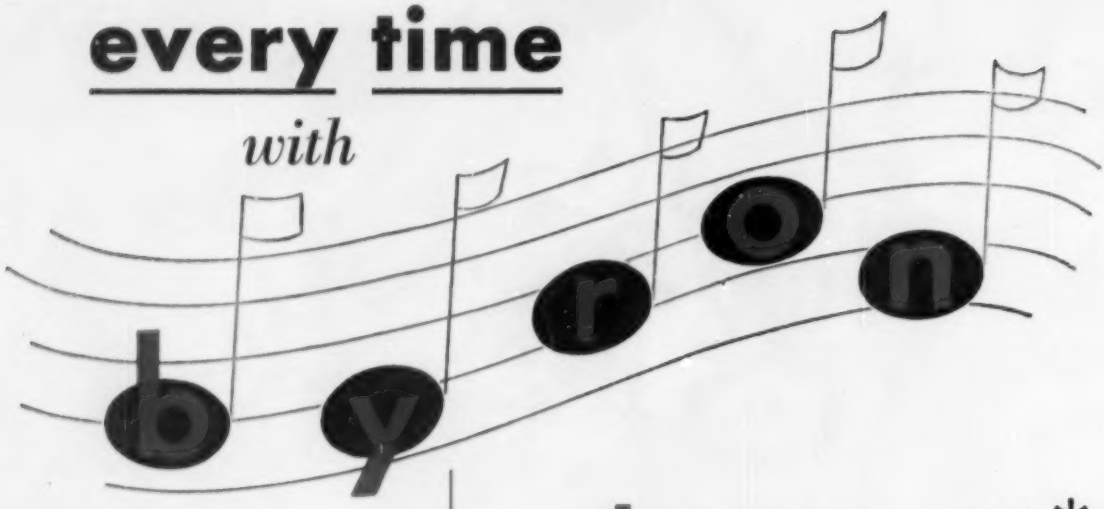
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Journals Available and Wanted

These notices are published as a service to expedite disposal and acquisition of out-of-print Journals. Please write direct to the persons and addresses listed.

Available

Dec., 1936; Jan., Feb., Apr., May, July, Sept., Nov. 1937; 1938 complete; 1939 complete; 1940 complete; Jan.–Aug. 1941. Write Richard S. Norton, Warner News Inc., 625 Madison Ave., New York, 22.

Collection of back issues available either singly or as a lot. Write F. H. Cole, 1258 So. Burnside Ave., Los Angeles 19.

Wanted

Complete set of Transactions. Write John Flory, Eastman Kodak Co., 343 State St., Rochester 4, N. Y.

High-Speed Photography, Volumes 1, 2 and 3. Write Jack Gershon, Armour Research Foundation, Technology Center, Chicago 16.

Transactions Nos. 6 and 9. Write W. W. Hennessy, 503 West 41 St., New York.

Signal Corps Pictorial Center could use a complete set of Journals, preferably as a donation. Write John P. Byrne, Motion Picture Sensitometrics, Signal Corps Pictorial Center, 45-15 48 St., Long Island City 4, N. Y.

Transactions Nos. 1, 5, 6, 7 and 9. Write Lloyd E. Varden, Pavelle Color Inc., 533 West 57 St., New York 19.

Meetings

SMPTE Central Section, Jan. 17, Feb. 21, Mar. 21, May 16, June 13.

Institute of the Aeronautical Sciences, Jan. 24–28, Hotel Astor, New York.

American Physical Society, Jan. 27–29, Hotels McAlpin and New Yorker, New York.

American Institute of Electrical Engineers, Winter General Meeting, Jan. 31–Feb. 4, Hotel Statler, New York.

Institute of Radio Engineers, National Convention, Mar. 21–24, Kingsbridge Armory, Bronx, N.Y.

Optical Society of America, Apr. 7–9, Hotel Statler, New York.

77th Semiannual Convention of the SMPTE, Apr. 18–22, Drake Hotel, Chicago.

National Academy of Sciences, Apr. 25–27, Washington, D.C.

American Physical Society, Apr. 28–30, Washington, D.C.

International Commission on Illumination, June 13–22, Zürich, Switzerland.

International Aeronautical Conference, joint mtg. of the British Aeronautical Society and the Institute of the Aeronautical Sciences, June 21–24, Los Angeles.

American Institute of Electrical Engineers, Summer General Meeting, June 27–July 1, New Ocean House, Swampscott, Mass.

Biological Photographic Association, Annual Meeting, Aug. 30–Sept. 2, Wisconsin Hotel, Milwaukee.

78th Semiannual Convention of the SMPTE, Oct. 3–7, Lake Placid Club, Essex County, N.Y.

American Institute of Electrical Engineers, Fall General Meeting, Oct. 3–7, Morrison Hotel, Chicago.

Photographic Society of America, Annual Convention, Oct. 5–8, Sheraton-Plaza Hotel, Boston, Mass.

American Standards Association, 37th Annual Meeting and Sixth Annual Conference on Standards, Oct. 24–26, Washington, D.C.

79th Semiannual Convention of the SMPTE, Apr. 29–May 4, 1956, Hotel Statler, New York.

80th Semiannual Convention of the SMPTE, Oct. 7–12, 1956, Ambassador Hotel, Los Angeles.

81st Semiannual Convention of the SMPTE, Apr. 28–May 3, 1957, Shoreham Hotel, Washington, D.C.

82d Semiannual Convention of the SMPTE, Oct. 6–11, 1957, Hotel Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April Journal.

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